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THE QUARTERLY REVIEW *of* BIOLOGY

THE TROPHIC NATURE OF THE PLANT-LIKE FLAGELLATES

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INTRODUCTION

THE Phytomastigophora, or plant-like flagellates, constitute an interesting group of borderline organisms. Recognized as Algae by botanists and as Protozoa by zoologists, their taxonomic status has long been disputed. Taxonomic compromises have been attempted. For example, Calkins (1933) has proposed the allocation of the chlorophyll-bearing species to the plant kingdom, retaining at the same time many of the colorless forms in Zoomastigophora. The advantages of such a disposition are debatable, since the effect would be the subdivision of a rather well defined group on the basis of inadequate morphological criteria.

The puzzling mixture of morphological characteristics in the Phytomastigophora is paralleled to some extent by certain physiological characteristics of these flagellates. Methods of nutrition range from holozoic in some colorless species to autotrophic (holophytic, or photoautotrophic) in certain of the chlorophyll-bearing types. Designation of a particular method of nutrition as characteristic of a given species is sometimes arbitrary and may even be inaccurate. Both holophytic and holozoic types may carry on saprozoic nutrition, and combinations of photosynthesis and holozoic nutrition are known. Moreover, certain "holophytic" species have been grown in darkness, thus being forced to depend entirely upon saprozoic nutrition. Furthermore, recent investigations indicate that certain species of *Euglena*—previously considered typical plant-like flagellates—are not autotrophic, since they are apparently unable to multiply in the absence of amino acids or peptones in spite of their ability to carry on photosynthesis. The present situation indicates the need for further investigation of nutrition in the plant-like flagellates.

METHODS OF NUTRITION

In the older terminologies, methods of nutrition in Protozoa were classified as *autotrophic* (= holophytic), *saprozoic* and *holozoic*, the last two sometimes being recognized as different varieties of *heterotrophic* nutrition. In autotrophic nutrition the organisms carry on photosynthesis and are capable of continued growth

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in a suitable inorganic medium. (The term *growth*, as used in the present discussion, refers to growth of populations and not to growth of individual cells.) The saprozoic types require organic compounds in solution, whereas holozoic organisms ingest solid food particles. The present tendency (e.g., Dusi, Lwoff, Pringsheim) is to introduce designations for various specialized types of nutrition. The following list represents a simplification of the terminologies introduced by several writers:

I. *Phototrophic nutrition:* exhibited by chlorophyll-bearing species; energy of light is utilized in photosynthesis; some species appear to be obligate phototrophs. On the basis of the simplest possible nitrogen requirements in each case, phototrophic nutrition may be subdivided as follows:
   (1) *Photoautotrophic nutrition:* characteristic of species which can grow in inorganic solutions; e.g., *Chlorogonium euchlorum*.
   (2) *Photomesotrophic nutrition:* exhibited by species which can grow in media containing amino acids but not in inorganic media; e.g., *Euglena deses*.
   (3) *Photometatrophic nutrition:* characteristic of species capable of growth in peptone solutions but not in amino-acid media or inorganic solutions; e.g., *Euglena pisciformis*.

II. *Chemoautotrophic nutrition:* described in certain bacteria capable of growth in inorganic media without utilizing energy of light; unknown in Protozoa.

III. *Heterotrophic nutrition:* characteristic of colorless organisms, for which an organic carbon source is necessary in the absence of chlorophyll. Some chlorophyll-bearing species can be grown in darkness and may, in this sense, be considered facultative heterotrophs. On the basis of nitrogen requirements, heterotrophic nutrition may be subdivided as follows:
   (1) *Heteroautotrophic nutrition:* utilization of inorganic compounds of nitrogen in the presence of an organic carbon source; e.g., *Polytoma uvella*.
   (2) *Heteromesotrophic nutrition:* growth requirements may be satisfied by one or more amino acids as sources of nitrogen and carbon; growth is usually more vigorous with an additional carbon source; e.g., *Polytomella caeca*.
   (3) *Heterometatrophic nutrition:* characteristic of organisms which grow in peptone solutions but not in amino-acid media or in inorganic solutions; e.g., *Hyalogenium klebsii*. This type of nutrition is also exhibited by those holozoic Protozoa (ciliates, amoebae) which have been grown in pure cultures.

Photoautotrophic nutrition

In any attempt to demonstrate photoautotrophic nutrition, the species in question must be carried through a series of transfers in a suitable inorganic medium. This series must be long enough to eliminate, by serial dilution, any organic foods carried over from the original stock culture, since traces of protein derivatives may be adequate for growth. Thus, *Chilomonas paramecium* (Hall and Loefer, 1936) has been grown in a salt solution containing peptone in a concentration of 5×10^{-6}, and *Euglena anabaena* (Hall and Schoenborn, 1938) in peptone concentrations of approximately 2.5×10^{-6} grams per cubic centimeter. In both instances, lower concentrations failed to support growth. Hence, it seems that serial dilution of organic foods from the original stock cultures should reach 10^{-10} or higher if conclusions regarding the autotrophic nature of an organism are to be valid. Such technique obviously demands both chemical cleanliness of glassware and bacterial sterility of the cultures, and the pure culture method thus affords the only logical approach to the study of autotrophic nutrition. The procedures followed by several investigators have been described elsewhere (Hall, 1937).

If the criteria of bacteria-free cultures and successive transfers in inorganic media are applied to the available evidence, surprisingly few examples of photoautotrophic flagellates are to be recognized. For the orders Chrysomonadida, Heterochlorida, Cryptomonadida, Dinoflagellida and

Chloromonadida, there is as yet no admissible evidence bearing on the problem of autotrophic nutrition.

A number of investigations have been carried out with Euglenida but the evidence is inconclusive in some cases, since different workers have reached contradictory conclusions for the same species. Pringsheim (1912), Mainx (1928) and Dusi (1930, 1930a, 1933) have reported that *Euglena gracilis* is a facultative autotroph. Hutner (1936), however, failed to grow the Mainx strain in inorganic media, and suggested that the findings of his predecessors might have resulted from errors in technique. More recently, Hall and Schoenborn (1939) have carried the same strain of *E. gracilis* through eleven transfers in inorganic media. In the eleventh transfer the peptone carried over from the original stock culture had been diluted to less than 7×10^{-18} grams per cubic centimeter.

The case of *E. anabaena* is somewhat similar. Dusi (1930a), working with the Mainx strain, concluded that the species is not photoautotrophic. After additional investigation, however, Dusi (1933a) reversed this opinion. Later, Hutner (1936) failed in his attempts to grow the Mainx strain in inorganic media, and Hall and Schoenborn (1938) were likewise unsuccessful with certain media, including the one Dusi considered most suitable for the species. More recently, the writer (Hall, 1938) has carried *E. anabaena* through nine successive transfers in a medium not previously tried for this species. Since the peptone concentration has already been reduced to 1.7×10^{-15} grams per cubic centimeter, this evidence supports Dusi's (1933a) opinion.

The trophic nature of several other species of *Euglena* has also been investigated. *E. deses*, according to Mainx (1928), is photoautotrophic. On the other hand, Dusi (1930, 1933a) and Hall and Schoenborn (1938) have been unable to agree with this conclusion. *E. viridis* was also considered photoautotrophic by Mainx, while Dusi (1936) has reported survival but no growth in inorganic media. Hall (1939), however, has grown the Mainx strain of this species for nine transfers in certain inorganic media, the calculated peptone concentration having been reduced to 1.9×10^{-14}. Mainx (1928) and Dusi (1930a, 1933a) have also disagreed on *E. pisciformis*, the latter concluding that the species is not autotrophic. Investigations in the writer's laboratory tend so far to support Dusi's conclusion. For *E. klebsii* and *E. stellata*, similar conclusions have been reached by Mainx and Dusi, and the photoautotrophic nature of these species is unquestioned. Mainx also reported that *Colacium vesiculosum*, *Euglena minima*, *E. mucosa* and *E. velata* are photoautotrophic. It should be pointed out, however, that Mainx did not subject his strains to successive transfers in inorganic media and that his best results were obtained when inorganic media were inoculated directly from stock cultures in ereptone media; hence, growth may possibly have been dependent upon organic materials carried into the inorganic solutions. Even with such methods, *E. olivacea* and *E. velata* grew very slowly, while *E. rubra* and *Phacus pleuronectes* usually failed to grow at all in inorganic solutions.

Obviously, the trophic nature of the Euglenidae as a group is somewhat uncertain. It is not impossible that, in an order containing colorless saprozoic and holozoic types as well as chlorophyll-bearing species, some of the green forms may have evolved, or degenerated, toward the saprozoic method of nutrition. Hence, recognition of certain species as photoautotrophs and of *E. deses* and *E.*

pisciformis as photomesotroph and photometatroph, respectively, may accurately represent the situation.

On the other hand, explanations must be found for the conflicting reports on certain species. Several possible explanations are apparent. In the first place, it is probable that differences in formulae of the media may be responsible for some of the differences in results. For example, most investigators have used a salt concentration of not more than 2.0 grams per liter, whereas "medium B" of Hutner (1936), in actual use, contained approximately 5.0 grams. Another illustration is Hutner's addition of sodium acetate to an inorganic medium, while Dusi (1930, 1930a, 1933, 1933a) used acetate-free solutions. Furthermore, Hutner used an acetate concentration of not less than 0.3 per cent for *Ea. nabaena* and *E. gracilis*, whereas a concentration of 0.05 per cent appears to be optimal for *E. stellata* (Hall, 1937a).

However, differences in formulae were not responsible for the findings of Hall and Schoenborn (1938), who tried Dusi's best medium, as well as several others, for *E. anabaena* and still were unable to grow this flagellate in inorganic solutions. Contradictory results of this type might be explained on the following basis. It is possible that media used in these investigations may be prepared according to the same formulae and yet differ in their content of elements essential for growth. Thus, an essential element might be present in traces in one preparation of a salt and be lacking in another which had been purified to a higher degree. This possibility is supported by the fact that Hall and Schoenborn (1939) obtained growth of *E. gracilis* in certain media to which manganese had been added, while previous attempts with several media presumably manganese-free had proven negative. The addition of manganese was suggested by earlier findings (Hall, 1937b) that this element accelerates growth of *E. anabaena* in organic and inorganic media. In addition to manganese, calcium may be important in autotrophic nutrition, since Dusi (1933a) found it necessary to add calcium to his media for best growth of *E. stellata*, and Hall and Schoenborn (1939) have obtained good results with *E. gracilis* in a medium containing calcium and manganese. The same calcium-manganese medium has also been used by Hall (1938, 1939) for *E. anabaena* and *E. viridis*.

The present lack of information concerning the inorganic substances essential to growth of Euglenidae and the optimal concentrations of such substances makes it difficult to conclude that any species is actually incapable of autotrophic nutrition. Growth requirements of these flagellates may be more exacting than formerly supposed, and negative results with any one species may mean only that the growth requirements have not yet been satisfied. Such species as *E. deses* and *E. pisciformis* should be investigated further with this possibility in mind before they are classified definitely as photomesotrophs or photometatrophs. However, until contradictory evidence is forthcoming, it must be admitted that at least some species of *Euglena* may not be photoautotrophic.

In the order Phytomonadida there is no such disagreement concerning photoautotrophic nutrition. Lwoff and Lwoff (1929) and Lwoff (1932) reported that both *Chlamydomonas agloëformis* and *Haematococcus pluvialis* are photoautotrophic. Mainx (1928) had reached the same conclusion for *Chlamydomonas umbonata*, although he did not use the technique of successive transfers. Loefer (1934) demonstrated that *Chlorogonium elongatum* and *C. euchlorum* are autotrophic. These obser-

vations on *C. euchlorum* were subsequently confirmed by Hall and Schoenborn (1938), who found that this species grew well in media which did not support growth of *Euglena anabaena* and *E. deses*. Investigations on Phytomonadida might well be extended to additional genera and species for the accumulation of more evidence, but it seems likely that photoautotrophic nutrition may prove to be a general characteristic of the chlorophyll-bearing species in this order.

Photomesotrophic and photometatrophic nutrition

These terms are applied to combinations of photosynthesis and saprozoic nutrition, as defined above, and may be exhibited by chlorophyll-bearing species grown in light in media containing suitable organic food. Certain species, e.g., *Euglena deses* (Dusi, 1933a), appear to be obligate photomesotrophs—that is, photomesotrophic nutrition is the simplest possible type; others (e.g., *E. pisciformis*) may be considered obligate photometatrophs. So far, investigations with pure cultures have been carried out only on certain Euglenidae and Phytomonadida.

The ability of chlorophyll-bearing species to carry on photometatrophic nutrition under suitable conditions appears to be widespread, according to reports of several workers, particularly Pringsheim, and the writer's own experience with stock cultures. The list of species which have been grown in peptone solutions includes more than a dozen Euglenidae and approximately 30 Phytomonadida. Loefer (1935a) found that, for *Chlorogonium elongatum* and *C. euchlorum*, a peptone of high amino-nitrogen content was most satisfactory, while casein and gelatin were much less satisfactory. Hutner (1936) reported that growth of *Euglena anabaena* is not supported by gelatin or casein, while Hall (1938) has since carried the same strain through 16 successive transfers in gelatin media for a period of 14 months.

Nitrogen requirements in photomesotrophic nutrition of Euglenidae have been the subject of a few investigations. Ternetz (1912) found that glycocoll, alanine and asparagin were good nitrogen sources for *E. gracilis*, and Pringsheim (1912) reported slow growth of the same species on amino-acid-agar media. Mainx (1928), on the other hand, obtained negative results in his attempts to grow several species of *Euglena* on single amino acids and artificial mixtures, although natural mixtures of amino acids, such as completely digested peptones, were satisfactory. Mainx suggested, therefore, that his preparations of amino acids might have contained traces of heavy metals in toxic concentrations. This suggestion is in accord with Dusi's (1931, 1933, 1933a) later findings that single amino acids will serve as sources of nitrogen for *E. anabaena* var. *minor*, *E. deses*, *E. gracilis*, *E. klebsii*, and *E. stellata*, but not for *E. pisciformis*. Thus, *E. pisciformis* is to be considered an obligate photometatroph, while the others are capable of photomesotrophic nutrition. Dusi's findings are particularly interesting in that they indicate specific differences in growth requirements. Thus, glycocoll did not support growth of *E. deses*, and yet was adequate for the other four species; phenylalanine gave negative results for *E. deses* and *E. klebsii* but supported growth of the other three; serine was adequate for growth of all save *E. anabaena*, and aspartic acid for all except *E. klebsii*. Analogous differences were observed for other amino acids. More recently, Dusi (1936) has obtained poor growth of *E. viridis* through three transfers in an asparagin medium, and has suggested that a complex source of nitrogen

may be essential for continued growth of the species. Hence, the ability of *E. viridis* to carry on photomesotrophic nutrition is uncertain. Hutner (1936) has been unsuccessful in attempts to grow *E. anabaena* and *E. gracilis* in media containing single amino acids or mixtures of several. On the other hand, the writer (Hall, 1938) has been more successful with *E. anabaena*, which is growing at present in the ninth transfers in glycocoll and asparagin media. An explanation for Hutner's failures is not yet available. At present, it seems probable that the majority of the Euglenidae will prove to be capable of carrying on photomesotrophic nutrition, although, in the absence of evidence to the contrary, *E. pisciformis* must be considered an obligate photometatroph.

For the Phytomonadida, the available evidence indicates that the ability to carry on photomesotrophic nutrition is characteristic of the chlorophyll-bearing species. Lwoff (1932) reported that asparagin, glycocoll and cystine each supported growth of *Chlamydomonas agloëformis* and *Haematococcus pluvialis*. Loefer (1932, 1935a) has observed, in *Chlorogonium elongatum* and *C. euchlorum*, acceleration of growth by glycocoll, valine, leucine, phenylalanine, tyrosine and asparagin. Whether each of these will support growth through successive transfers has not been determined.

Growth of chlorophyll-bearing species in amino-acid media (photomesotrophic nutrition) and in peptone media (photometatrophic nutrition) is accelerated by the addition of a suitable carbon compound.

Under both conditions, Lwoff (1932) has described such effects of sodium acetate for *Chlamydomonas agloëformis*, *Haematococcus pluvialis* and *Euglena gracilis*. Other workers have reported similar observations on *E. gracilis* (Dusi, 1933; Provasoli, 1938) and *Euglena* sp. (Provasoli, 1938). The effects of several salts of organic acids on growth of *E. gracilis* have been compared quantitatively by Jahn (1935b), and the effects of different concentrations of acetate on growth of *E. stellata* have been determined by Hall (1937a). Growth of *E. gracilis* (Jahn, 1935) is accelerated also by soluble starch and, under certain conditions, by several other carbohydrates. In addition, ethyl alcohol (Loefer and Hall, 1936) accelerates growth of *E. deses* and *E. gracilis*. For *Chlorogonium elongatum* and *C. euchlorum*, Loefer (1933, 1935) has reported marked acceleration of growth by levulose, galactose, maltose and lactose, and less noticeable effects by rhamnose, dextrose, xylose and arabinose. In addition to these more detailed observations, the writer has noted, in a comparison of various stock peptone media, that sodium acetate accelerates growth of the following species: *Euglena anabaena*, *E. deses*, *E. gracilis*, *E. klebsii*, *E. pisciformis*, *E. stellata*, *E. viridis* (Euglenidae); and *Chlamydomonas agloïformis*, *C. dorsoventralis*, *C. oblonga*, *C. oviformis*, *C. proteus*, *C. pulchra*, *C. subtilis*, *C. umbonata*, *Chlorogonium elongatum*, *C. euchlorum*, *Haematococcus pluvialis*, *Lobomonas piriformis* (Phytomonadida).

Heteroautotrophic nutrition

The term *heteroautotrophic* has been applied by Pringsheim (1937b) to flagellates which can utilize inorganic nitrogen (e.g., ammonium salts) in the presence of an organic source of carbon, such as sodium acetate. The case of *Chilomonas paramecium* is in dispute. Mast and Pace (1933) reported that this species grows in a medium containing ammonium chloride as the source of nitrogen. Loefer (1934), on the other hand, was unsuccessful in attempts to grow the flagellate in inorganic media, and Pringsheim (1935) likewise was unable to substantiate the findings of Mast and Pace. Later, Hall and Loefer (1936) tried "solution D" of Mast and Pace as well as several other media, again with negative results. These conflicting results raise the possibility that different strains of a given species may differ in trophic nature. Or such differences in results might depend upon chemical differences in media not indicated in published formulae, as suggested above for Euglenidae.

A more firmly established case of hetero-

autotrophic nutrition is that of *Polytoma uvella*. Pringsheim (1921) reported that, as nitrogen sources, ammonium salts in the presence of acetate are just as satisfactory as amino acids. Comparable results have been obtained more recently by Lwoff (1929, 1931, 1932), and additional observations have since been published by Pringsheim (1937a).

Heteromesotrophic and heterometatrophic nutrition

These types of nutrition involve utilization of organic compounds of nitrogen—amino acids in the former, and more complex compounds in the latter. Such methods of nutrition are characteristic of Phytomastigophora without chromatophores, and may in some cases be imposed upon chlorophyll-bearing species by maintaining cultures in darkness. This change from phototrophic to heterotrophic nutrition may, in the green species, be correlated with physiological modifications not yet understood. Thus, Elliott (1937) has shown that growth of *E. gracilis* in darkness is not accelerated by several plant hormones, whereas marked effects are to be observed in light. These same plant hormones produce no effect on growth of the colorless euglenoid, *Khawkinea halli* (Elliott, 1938). Hence, with respect to action of the plant hormones, *E. gracilis* in darkness is similar to a related colorless species. Jahn (1935b) has found that sodium succinate, in certain concentrations, accelerates growth of *E. gracilis* in darkness but is slightly toxic to the flagellates in light. Also, relatively greater acceleration of growth was produced by butyrate, acetate and lactate in darkness than in light. The observations of Hall (1937a) on *E. stellata* are comparable, since growth of this flagellate in light was decreased by the higher concentrations of sodium acetate which accelerated growth in darkness.

In the writer's laboratory, the following species have been grown successfully in various peptone media (heterometatrophic nutrition)

Chilomonas paramecium (strain J-L), *Astasia longa* (Pringsheim strain), *Astasia quartana* (Pringsheim strain), *Astasia* sp. (strain J), a colorless strain of *Colacium vesiculosum*, *Khawkinea halli* (strain J), *Polytomella caeca* (Pringsheim strain), *Polytoma uvella* (Pringsheim strain). To this list may be added *Hyalogonium klebsii* (Pringsheim, 1937), *Polytoma caudatum* var. *astigmata* (Lwoff and Provasoli, 1935), *Polytomella agilis* (Lwoff, 1935a), *Chilomonas oblonga* (Pringsheim, 1937c), *Polytoma ocellatum* (Pringsheim, 1937c), *Astasia chattoni* (Lwoff and Dusi, 1934, 1936), and a colorless strain of *Euglena mesnili* (Lwoff and Dusi, 1935).

It thus appears that all of the colorless Phytomastigophora so far investigated are capable of carrying on heterometatrophic nutrition.

Only a few detailed observations on nitrogen sources in heterometatrophic nutrition have been completed. Loefer (1932, 1935a) has compared a series of different peptones and proteins as food for *Chilomonas paramecium*. Most rapid growth was observed in a peptone of comparatively high amino-nitrogen content, and relatively slow growth in unhydrolyzed proteins such as casein and gelatin. Several peptones have also been compared as to their availability for *Hyalogonium klebsii* (Pringsheim, 1937), and for *Polytoma uvella* and *Polytomella caeca* (Pringsheim, 1937a).

Heteromesotrophic nutrition has been investigated in several species. Mast and Pace (1933) reported that glycocoll is adequate for growth of *Chilomonas paramecium*, and this was later confirmed by Hall and Loefer (1936). Mainx (1928) was unable to grow *Astasia ocellata* on single amino acids or artificial mixtures, and the ability of any species of *Astasia* to carry

on heteromesotrophic nutrition is uncertain. Pringsheim (1921) found that glycocoll and certain other amino acids support only slow growth of *Polytoma uvella*, while a medium containing glycocoll and sodium acetate is quite satisfactory. According to Lwoff and Dusi (1934), this species also grows very poorly in an asparagin medium but quite vigorously with an additional carbon source such as sodium acetate. *Polytomella caeca* (Pringsheim, 1935, 1937a) likewise grows in amino-acid media containing sodium acetate, while both *Polytomella agilis* (Lwoff, 1935a) and *Polytoma caudatum* var. *astigmata* (Lwoff and Provasoli, 1935) grow slowly in asparagin media but rapidly with added acetate. *Polytoma* and *Polytomella* are thus able to carry on heteromesotrophic nutrition. *Hyalogonium klebsii* (Pringsheim, 1937), on the other hand, is an obligate heterometatroph which requires peptones for growth.

The effects of added carbon sources on growth of several colorless species have been determined. Loefer (1935) found that, for *Chilomonas paramecium*, marked acceleration of growth was produced by dextrin, and less noticeable effects by levulose, galactose, lactose, maltose, arabinose and dextrose. Among the salts of various fatty acids (Loefer, 1933, 1935), acetate, butyrate, valerate and proprionate —in descending order—were most effective. Similar effects of acetate have been reported for other strains of *C. paramecium* (Lwoff and Dusi, 1934; Pringsheim, 1935, 1937c), and growth of *C. oblonga* is accelerated, in addition, by salts of butyric, isobutyric, propionic, valeric, pyruvic and succinic acids. *Chilomonas* thus appears to utilize several carbohydrates and organic acids as sources of carbon. Fermentation of carbohydrates, however, has not yet been demonstrated, and Loefer (1937) has obtained no evidence that *C. paramecium* utilizes appreciable quantities of dextrose over short periods of incubation.

Among the colorless Euglenidae, growth of *Astasia chattoni* (Lwoff and Dusi, 1934) is accelerated by acetate, lactate and pyruvate, and also (according to Lwoff and Dusi, 1936) by propionate, butyrate, caproate and valerate. Pringsheim (1937c) has reported, for *A. longa*, acceleration of growth by acetate, propionate, butyrate, isobutyrate, malate and succinate, while growth of *A. quartana* is affected by only the first three salts. For the last species, however, Provasoli (1938) has obtained acceleration of growth with several salts which gave negative results in Pringsheim's experiments.

Similar effects have been noted in some of the colorless Phytomonadida. Growth of *Polytoma uvella* (Pringsheim, 1937a, c) is increased by acetate, butyrate, lactate and succinate and, according to Lwoff and Dusi (1934), also by starch; one of Pringsheim's (1937c) strains of *P. ocellatum*, by acetate, butyrate, isobutyrate, valerate, malate, lactate and succinate; a second strain (Pringsheim, 1937c) of the same species, only by acetate, proprionate and isobutyrate; *P. caudatum* var. *astigmata* (Lwoff and Provasoli, 1935), by acetate, butyrate, pyruvate and starch; *Polytomella caeca* (Pringsheim, 1937a, c), by acetate, butyrate, proprionate, valerate, isobutyrate, lactate and succinate; *P. agilis* (Lwoff, 1935a), by acetate, butyrate, propionate, valerate, caproate, isobutyrate and starch; *Hyalogonium klebsii* (Pringsheim, 1937, 1937c), only by acetate and succinate. Such observations point out interesting differences in the variety of carbon compounds utilized by colorless Phytomonadida. Such differences are exhibited not only by different species, but also by different strains of the same species (Pringsheim, 1937c).

In darkness the chlorophyll-bearing Phytomastigophora must, if they continue to grow, carry on either heteromesotrophic or heterometatrophic nutrition. Heterometatrophic nutrition in darkness has been reported for several Phytomonadida: *Chlamydomonas agloëformis* (Lwoff and Lwoff, 1929; Lwoff, 1932), *Chlorogonium elongatum* (Loefer, 1934), *C. euchlorum* (Loefer, 1934; Lwoff and Dusi, 1935a), *Haematococcus pluvialis* (Lwoff and Lwoff, 1929; Lwoff, 1932). In all cases growth in darkness is accelerated by the addition of acetate, or some other suitable carbon compound, to the medium. Loefer (1935) has compared the effects of eleven carbohydrates and of several fatty acids on growth of *C. elongatum* and *C. euchlorum*. Of the carbohydrates, levulose was most effective, and the other results were similar to those for cultures grown in light. Of the fatty acid salts, growth was accelerated—in descending order—by acetate, butyrate, valerate and isobutyrate. Lwoff and Dusi (1935a) reported that, for *C. euchlorum*, acetate, pyruvate, and soluble starch were most effective of a number of fatty acid salts and carbohydrates.

The ability of Euglenidae to carry on heteromesotrophic nutrition in darkness is yet to be demonstrated. However, heterometatrophic nutrition in darkness has been described for *Euglena mesnili* by Lwoff and Dusi (1935), for *Euglena* sp. by Provasoli (1938), and for *E. gracilis* by Zumstein (1899), Pringsheim (1912), Ternetz (1912), Mainx (1928), Lwoff and Dusi (1929, 1934), Jahn (1935a, b). Much heavier growth was noted by Lwoff and Dusi when sodium acetate was added to the medium. Similar results were obtained by Jahn, who has compared quantitatively the effects of various organic acids on growth of *E. gracilis*. On the other hand, some of the Euglenidae appear to be incapable of continued growth in darkness. Thus, Dusi (1933a) has reported that *E. anabaena* var. *minor*, *E. deses*, *E. klebsii*, *E. pisciformis* and *E. stellata* will not grow in darkness even with such a carbon source as sodium acetate. Hall (1933) also observed that growth of *E. anabaena* in peptone media is very slow in darkness, while that of *E. deses* is insignificant. In the case of *E. anabaena* (Hall, 1934) significant acceleration of growth in darkness is produced by the addition of dextrose, levulose or maltose to a peptone medium, while growth in other carbohydrate media is not appreciably greater than that in the controls. No attempt was made to carry the strain through a series of transfers in darkness. *E. stellata* (Hall, 1936), however, has shown growth through several transfers in a medium containing peptone and sodium acetate.

DISCUSSION

In the present survey it has been pointed out that certain of the chlorophyll-bearing Phytomonadida are capable of carrying on photoautotrophic nutrition under suitable conditions and, so far as the evidence extends, are all capable of heteromesotrophic nutrition when grown in darkness. This group includes all those species which have been investigated adequately: *Chlamydomonas agloëformis*, *Chlorogonium elongatum*, *C. euchlorum*, *Haematococcus pluvialis*. While the accumulation of additional evidence is desirable, it seems probable that photoautotrophic nutrition will prove to be characteristic of chlorophyll-bearing Phytomonadida. This assumption is in accord with the current generalization that the chylrophyll-bearing members of this order are the most "plant-like" of all the Phytomastigophora.

The colorless Phytomonadida, however, show interesting differences in growth requirements. *Polytoma uvella* may carry

on heteroautotrophic nutrition. On the other hand, *P. caudatum* var. *astigmata* and *Polytomella caeca* appear to have lost this ability, and must be considered heteromesotrophs. *Hyalogonium klebsii* stands apart as an obligate heterometatroph which is dependent upon peptones. Even in the Phytomonadida, therefore, there is an apparent trend toward methods of nutrition characteristic of the more "animal-like" Protozoa.

The trophic nature of the chlorophyll-bearing Euglenidae does not show the uniformity noted in the green Phytomonadida. In the light of present evidence, *E. gracilis*, *E. klebsii* and *E. stellata* may be recognized as photoautotrophs. The autotrophic status of *E. anabaena* is somewhat less certain, while the trophic nature of *E. viridis* is yet in dispute. *E. deses* and *E. pisciformis* appear to be incapable of growth in inorganic media. *E. deses* has been grown on amino acids, and may be considered photomesotrophic, whereas *E. pisciformis* apparently requires peptones and must be classified as an obligate photometatroph. Additional species investigated by Mainx (1928) have not been tested by the method of successive transfers.

In darkness, *E. gracilis* can be grown in peptone media and, in that sense, is no longer dependent upon photosynthesis. Similarly, *E. mesnili* has been grown in darkness and a strain without chlorophyll also has been maintained in the laboratory by Lwoff and Dusi. Certain species, however, appear to be dependent upon light. Thus there is no evidence that *E. anabaena*, *E. deses*, *E. klebsii* and *E. pisciformis* are capable of continued growth in darkness. Hence, it is necessary to recognize, within the genus *Euglena*, photoautotrophic species, photomesotrophic species, and photometatrophic species; obligate phototrophs, which are incapable of growth in darkness, and facultative heterotrophs, which can be grown indefinitely in darkness. The evolutionary trend, away from the primitive autotrophic condition, appears to be well marked in the green Euglenidae, and such physiological specialization is not surprising in an order which has evolved free-living saprozoic and holozoic types as well as several parasitic species.

The need for additional investigations on the nutrition of plant-like flagellates is obvious. Only with more detailed information will it be possible to decide whether certain species are photoautotrophic or have really lost this primitive characteristic. Such information may also explain the differences in results obtained by various workers. Investigations have been limited so far to the Euglenida, Phytomonadida and a few Cryptomonadida, and none of the holozoic members of these groups has yet been grown in pure culture. The other orders are not yet represented by bacteria-free strains. The application of the pure-culture technique to these orders and to additional species of Cryptomonadida, Euglenida and Phytomonadida should afford solutions to many interesting problems. Evidence already accumulated indicates that the evolution of colorless flagellates has been accompanied by fundamental changes in physiological characteristics, and an understanding of such modifications is dependent upon more widely extended investigations. The little information now available suggests that some of the plant-like flagellates approach, in their growth requirements, the Zoomastigophora, Ciliata and Amoebida which have been established in pure cultures. Investigations in this field may eventually throw some light on the evolution of other groups of Protozoa from the plant-like flagellates.

LITERATURE CITED

CALKINS, G. N. 1933. The Biology of the Protozoa. (*Philadelphia*, Lea and Febiger), 607 pp.

DUSI, H. 1930. La nutrition autotrophe d'*Euglena gracilis* Klebs aux dépens de quelques azotés inorganiques. *C. R. Soc. Biol.*, 104: 662–664.

——. 1930a. Pouvoir de synthèse de quelques Euglènes: Euglènes autotrophes et Euglènes hétérotrophes. *Ibid.*, 105: 837–839.

——. 1931. L'assimilation des acides aminés par quelques Eugléniens. *Ibid.*, 107: 1232–1234.

——. 1933. Recherches sur la nutrition de quelques Euglènes. I. *Euglena gracilis*. *Ann. Inst. Pasteur*, 50: 550–597.

——. 1933a. Recherches sur la nutrition de quelques Euglènes. II. *Euglena stellata, klebsii, anabaena, deses* et *pisciformis*. *Ibid.*, 50: 840–890.

——. 1936. Recherches sur la culture et la nutrition d'*Euglena viridis* Ehrbg. *Arch. zool. expér. et gén.*, 78 (N. & R.): 133–136.

ELLIOTT, A. M. 1937. Plant hormones and growth of *Euglena* in relation to light. *Anat. Rec.*, 70 (Suppl.): 128 (Abstract).

——. 1938. The influence of certain plant hormones on growth of Protozoa. *Physiol. Zool.*, 11: 31–39.

HALL, R. P. 1933. On the relation of hydrogen-ion concentration to the growth of *Euglena anabaena* var. *minor* and *E. deses*. *Arch. f. Protistenk.*, 79: 239–248.

——. 1934. Effects of carbohydrates on growth of *Euglena anabaena* var. *minor* in darkness. *Ibid.*, 82: 45–50.

——. 1936. Growth of *Euglena stellata* in darkness. *Anat. Rec.*, 67 (Suppl.): 120 (Abstract).

——. 1937. "Growth of free-living Protozoa in pure cultures" *in* Culture Methods for Invertebrate Animals. (Comstock, *Ithaca*), pp. 51–59.

——. 1937a. Effects of different concentrations of sodium acetate on growth of *Euglena stellata*. *Anat. Rec.*, 70 (Suppl.): 127 (Abstract).

——. 1937b. Effects of manganese on the growth of *Euglena anabaena, Astasia* sp. and *Colpidium campylum*. *Arch. f. Protistenk.*, 90: 178–184.

——. 1938. Nitrogen requirements of *Euglena anabaena*. *Arch. f. Protistenk.*, 91: 465–473.

——. 1939. The trophic nature of *Euglena viridis*. *Arch. zool. expér. et gén.* (In press).

HALL, R. P., and LOEFER, J. B. 1936. On the supposed utilization of inorganic nitrogen by the colorless cryptomonad flagellate, *Chilomonas paramecium*. *Protoplasma*, 26: 321–330.

HALL, R. P., and SCHOENBORN, H. W. 1938. Studies on the question of autotrophic nutrition in *Chlorogonium euchlorum, Euglena anabaena* and *E. deses*. *Arch. f. Protistenk.*, 90: 259–271.

——. 1939. The question of autotrophic nutrition in *Euglena gracilis*. *Physiol. Zool.*, 12: 76–84.

HUTNER, S. H. 1936. The nutritional requirements of two species of *Euglena*. *Arch. f. Protistenk.*, 88: 93–106.

JAHN, T. L. 1935. Studies on the physiology of the euglenoid flagellates. V. The effect of certain carbohydrates on the growth of *Euglena gracilis* Klebs. *Arch. f. Protistenk.*, 86: 238–250.

——. 1935a. Studies on the physiology of the euglenoid flagellates. VI. The effects of temperature and of acetate on *Euglena gracilis* cultures in the dark. *Ibid.*, 86: 251–257.

——. 1935b. Studies on the physiology of the euglenoid flagellates. VII. The effect of salts of certain organic acids on growth of *Euglena gracilis* Klebs. *Ibid.*, 86: 258–262.

LOEFER, J. B. 1932. Effects of certain amino acids on growth of *Chlorogonium* and *Chilomonas*. *Anat. Rec.*, 54 (Suppl.): 103 (Abstract).

——. 1933. Effects of salts of certain fatty acids on growth of *Chilomonas* and *Chlorogonium*. *Ibid.*, 57 (Suppl.): 95 (Abstract).

——. 1934. The trophic nature of *Chlorogonium* and *Chilomonas*. *Biol. Bull.*, 66: 1–6.

——. 1935. Effects of certain carbohydrates and organic acids on growth of *Chlorogonium* and *Chilomonas*. *Arch. f. Protistenk.*, 84: 456–471.

——. 1935a. Effects of certain nitrogen compounds on growth of *Chlorogonium* and *Chilomonas*. *Ibid.*, 85: 74–86.

——. 1937. Quantitative determination of dextrose in cultures of *Colpidium, Glaucoma, Chilomonas* and *Chlorogonium*. *Anat. Rec.*, 70 (Suppl.): 42 (Abstract).

LOEFER, J. B., and HALL, R. P. 1936. Effects of alcohol on growth of eight protozoan species in bacteria-free culture. *Arch. f. Protistenk.*, 87: 123–130.

LWOFF, A. 1929. La nutrition de *Polytoma uvella* Ehrenberg (Flagelle Chrysomonadinae) et le pouvoir de synthèse des protistes hétérotrophes. Les protistes mésotrophes. *C. R. Ac. Sci.*, 188: 114–116.

——. 1931. La nutrition carbonée de *Polytoma uvella*. *C. R. Soc. Biol.*, 107: 1070–1071.

——. 1932. Recherches biochimiques sur la nutrition des Protozoaires. Le pouvoir synthèse. Monographies de l'Institut Pasteur (*Paris*, Masson et Cie.), 158 pp.

——. 1935. L'oxytrophie et les organismes oxytrophes. *C. R. Soc. Biol.*, 119: 87–90.

LWOFF, A. 1935a. La nutrition azotée et carbonée de *Polytomella agilis* (Polyblépharidée incolore). *Ibid.*, 119: 974–976.

LWOFF, A., and DUSI, H. 1929. Le pouvoir synthèse d'*Euglena gracilis* cultivée à l'obscurité. *Ibid.*, 102: 567–569.

——. 1931. La nutrition azotée et carbonée d'*Euglena gracilis* en culture pure à l'obscurité. *Ibid.*, 107: 1068–1069.

——. 1934. L'oxytrophie et la nutrition des flagellés leucophytes. *Ann. Inst. Pasteur*, 53: 641–653.

——. 1935. La suppression expérimentale des chloroplastes chez *Euglena mesnili*. *C. R. Soc. Biol.*, 119: 1092–1095.

——. 1935a. La nutrition azotée et carbonée de *Chlorogonium euchlorum* à l'obscurité; l'acide acetique envisagé comme produit de l'assimilation chlorophylliene. *Ibid.*, 119: 1260–1263.

——. 1936. La nutrition de l'Euglénien *Astasia chattoni*. *C. R. Ac. Sci.*, 202: 248–250.

LWOFF, A., and PROVASOLI, L. 1935. La nutrition de *Polytoma caudatum* var. *astigmata* (Chlamydomonadine incolore), et la synthèse de l'amidon par les leucocytes. *Ibid.*, 119: 90–93.

LWOFF, M., and LWOFF, A. 1929. Le pouvoir de synthèse de *Chlamydomonas agloëformis* et d'*Haematococcus pluvialis*. *Ibid.*, 102: 569–571.

MAINX, F. 1928. Beiträge zur Morphologie und Physiologie der Eugleninen. II. Teil. Untersuchungen über die Ernährungs- und Reizphysiologie. *Arch. f. Protistenk.*, 60: 355–414.

MAST, S. O., and PACE, D. M. 1933. Synthesis from inorganic compounds of starch, fats, proteins and protoplasm in the colorless animal, *Chilomonas paramecium*. *Protoplasma*, 20: 326–358.

PRINGSHEIM, E. G. 1912. Kulturversuche mit chlorophyllführenden Mikroorganismen. II. Zur Physiologie der *Euglena gracilis*. *Beitr. z. Biol. d. Pflanz.*, 12: 1–47.

——. 1921. Zur Physiologie saprophytischer Flagellaten (*Polytoma*, *Astasia* und *Chilomonas*). *Beitr. Allg. Bot.*, 2: 88–138.

——. 1935. Über Azetatflagellaten. *Die Naturwiss.*, 23: 110–114.

——. 1937. Beiträge zur Physiologie saprophytischer Algen und Flagellaten. 1. Mitt. *Chlorogonium* und *Hyalogonium*. *Planta, Arch. f. wiss. Bot.*, 26: 631–664.

——. 1937a. Beiträge zur Physiologie saprophytischer Algen und Flagellaten. 2. Mitt. *Polytoma* und *Polytomella*. *Ibid.*, 26: 665–691.

——. 1937b. Beiträge zur Physiologie saprophytischer Algen und Flagellaten. 3. Mitt. Die Stellung der Azetatflagellaten in einem physiologischen Ernährungssystem. *Ibid.*, 27: 61–92.

——. 1937c. Assimilation of different organic substances by saprophytic Flagellatae. *Nature*, 139: 196.

PROVASOLI, L. 1938. Remarques sur la nutrition carbonée des Eugléniens. *C. R. Soc. Biol.*, 127: 190–192.

TERNETZ, C. 1912. Beiträge zur Morphologie und Physiologie der *Euglena gracilis* Klebs. *Jahrb. f. wiss. Bot.*, 51: 435–514.

ZUMSTEIN, H. 1899. Zur Morphologie und Physiologie der *Euglena gracilis*. *Ibid.*, 34: 149–196.

ADOLESCENT STERILITY

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"Where Nature indicates a fact, we do well to attend to her instruction."
J. M. Waddy, 1846.

ADOLESCENCE (Middle English *ad*, to, + *olescere*, the inceptive form of *olere* [?], grow) means literally the state of growing. Specifically the term is applied to that period of life which falls between puberty and the full development of the body; a period generally assumed to extend in man from about 13 to 23 years of age. Naturally a period of such importance has attracted many students, as the very considerable literature devoted to the study of adolescence attests. In recent years the most significant contribution to our understanding of the biology of adolescence has come from the field of endocrinology. A number of the endocrine glands have been shown to represent the fundamental agents in the determination and regulation of the processes of development, particularly during the period of adolescence. And in this connexion the findings of endocrinologists make necessary the revision of our conceptions of the phases of the developmental period of adolescence. Puberty, menarche, maturity, and adolescence are terms which today are all too loosely used, yet the phenomena which they embrace are capable of precise and fairly exact definition. Such definitions will be attempted in the course of this paper.

As is well known, the arrival of puberty is generally regarded as a condition which, in the female, is marked by the appearance of the first menstruation, or the menarche; this event is practically universally taken to be coincident with the establishment of the capacity to reproduce. The root of the word puberty, *pu*, actually means *to beget*. Thus, puberty, menarche, and the development of the capacity to reproduce are regarded as synchronous 'events' which may be referred to by terms of synonymous and assumed equal value. Certainly every dictionary makes the identity of this triad complete, and almost all contemporary writers, with very few exceptions, do so. Puberty is regarded as a moment in time determined by the arrival of the menarche, an event which is in turn taken to signalize the development of the capacity to reproduce.

Modern research on the reproductive physiology and growth of mammals such as the mouse, rat, macaque, chimpanzee, and man, very strongly suggests that puberty, menarche, and the development or attainment of the capacity to reproduce are phenomena by no means so closely associated with one another as has hitherto been supposed, but rather that they are distinctly separable phenomena both in time and in character. It now

appears fairly certain that puberty itself properly represents an extended process of development, rather than an event or a moment in time; and that it is during the progress of this developmental process that menarche is gradually established, and reproductive capacity only very rarely. Puberty does not mark a stage of development, but represents more clearly a *phase* of development. Menarche represents a stage in that particular phase of development, the stage of beginning (anovulatory) ovarian activity. The capacity for reproduction generally follows appreciably later. The attainment of this capacity marks the termination of the period of puberty and the initiation of the period of nubility which, in the human species, terminates in the period of maturity only after the lapse of some years in time, and much increase in size and differentiation of various organs.

The interval between the establishment of menarche, or the so-called arrival of puberty, and the establishment of the capacity to reproduce, appears to be a normal feature of the developmental physiology of all the lower mammals thus far investigated. In the present paper it is proposed to inquire into the existence of such a period of adolescent sterility in the human female. The way for such a study has already been prepared by the writings of C. G. Hartman who, among contemporary students of reproductive physiology, was the first to suggest that the human adolescent female was probably characterized by a period of relative sterility during the first part of this phase of her development. Himes (57), Zuckerman (146), Mills and Ogle (78), Schultz and Snyder (111), Ashley-Montagu (6, 7, 8, 9), Engle (36), Mikulicz-Radecki and Kausch (149), Greulich (43), Shuttleworth (115), and Pearl (150), have all recently referred to this phenomenon with special reference to its applicability to the human species, so that the idea of the possible existence of such a period of adolescent sterility in man already enjoys a certain currency.

In recent years the first observers to draw attention to the phenomenon of the infertility of adolescent human females have been ethnologists.

Working in the field ethnologists have more than once been puzzled by the fact that in the societies studied by them the unmarried post-pubertal females, despite free and frequent intercourse with mature males, rarely become pregnant or bear children. Thus, for example, in 1926 Rivers (105) remarked in connection with the Eddystone Islanders of Melanesia studied by Hocart and himself that:

> the very free relations existing before marriage might have been expected to lead to the birth of many children and to the existence of definite regulations for assigning such children to their proper place in society. Such births seemed, however, to be extremely rare, and in the whole of the pedigrees collected by us only one such case was given, and that many generations ago. We did not hear of any such birth either during our visit or in recent times; and so far as we know there was no one on this island who was the child of premarital intercourse. It was said that such births occurred, however, though no actual recent instances could be given.

Rivers goes on to say that "It is quite certain that births before marriage were very rare and two causes were given to account for this, abortion and a process resembling the other magico-religious rites of the island, called *egoro*, meaning 'barrenness,' which is believed to prevent conception."

Where information was available it appeared that women produced abortion by mechanical means, or by the process of rubbing a certain leaf, which had previously been heated, over the belly, and

finally by holding four leaves of another variety beneath the vulva, when, it was said, the child would 'come out.'

From Rivers' description of an *egoro* rite, the details of which need not be discussed here, it is perfectly clear that the rite is a purely magical one, and can have had no possible physical effect upon the woman. This becomes even more clear when we learn that the rite is believed to be quite as efficacious in producing sterility in the woman when it is performed upon her husband alone! Rivers does to some extent recognize the magical nature of the rite, but he nonetheless considers it quite possible that the concoctions used may actually produce some pathological condition of the uterus in the woman. This, however, is pure assumption and as an explanation of the condition of infertility among the unmarried women will manifestly not do; for it is obvious that a fairly large proportion of the Eddystone Islanders must be fecund, and that the rarity of births among the unmarried is, at least in part, due to the fact that though there may have been much intercourse, relatively few pregnancies have resulted therefrom.

In 1929 among the Trobriand Islanders of North-Western Melanesia Malinowski (71), observed that:

> . . . it is very remarkable to note that illegitimate children very rare. The girls seem to remain sterile throughout their period of licence, which begins when they are small children and continues until they marry; when they are married they conceive and breed, sometimes quite prolifically. . . . I was able to find roughly a dozen illegitimate children recorded genealogically in the Trobriands, or about one per cent. . . .
>
> Thus we are faced with the question: Why are there so few illegitimate children? On this subject I can only speak tentatively, and I feel that my information is perhaps not quite as full as it might have been, had I concentrated more attention upon it. One thing I can say with complete confidence: no preventive means of any description are known nor the slightest idea of them entertained. This, of course, is quite natural. Since the procreative power of seminal fluid is not known, since it is considered not only innocuous but beneficient, there is no reason why the natives should interfere with its free arrival into the parts which it is meant to lubricate. Indeed, any suggestion of neo-Malthusian appliances makes them shudder or laugh according to their mood or temperament. They never practise *coitus interruptus*, and still less have any notion about chemical or mechanical preventives.
>
> But though I am quite certain on this point, I cannot speak with the same conviction about abortion, though probably it is not practised to any large extent. . . .
>
> So the problem remains. Can there be any physiological law which makes conception less likely when women begin their sexual life young, lead it indefatigably, and mix their lovers freely?

There has been some question concerning the accuracy of Malinowski's observations (103), but it has recently been independently established that these observations are in all particulars correct and confirmable (10, 104).

A very illuminating account of conditions prevailing among the natives of Wogeo, one of the most northerly of the Schouten Islands in the territory of New Guinea, has recently been given by Hogbin (58). Among the natives of this island sexual life does not begin until about the age of sixteen or seventeen years, or even later, whenafter it is particularly free. Hogbin wrote in 1935:

> Single girls do sometimes have children, but illegitimacy is not nearly so common as one might have expected. Just why this is so it is impossible to say. Professor Malinowski, it will be remembered, found the same situation in the Trobriands. I observed one fact that bears directly on the problem, namely that it is extremely rare for women to have children until they are, I judge, more than 21 years of age, by which time most of them are safely married. I have noticed that even when a girl is married directly after her first menstruation, which does not regularly take place until almost certainly after the seventeenth year, it is most unusual for her to have a child for several years. One Dap girl had a child

within about eighteen months of her first menstruation—fortunately for herself she was married—and this was so unusual that she was described as a coconut putting forth a shoot before it had fallen from the parent tree. The comments on this girl, in fact, brought the whole matter to my notice.

Although the ages which Hogbin gives are admittedly only approximate, it was possible to check them fairly closely by reference to certain historic events known both to the investigator and to the islanders. It may appear to some that seventeen is rather a late age for the appearance of the first menstruation, especially in the Tropics, but the fact is that both the earliest (106) and the latest reliable evidence (25, 79), indicates very strongly that menarche generally occurs later among girls living in the Tropics than among those living in cooler climes.

In connexion with Melanesian peoples generally the investigations of Reche (101) on the Matupi of New Pomerania are of great interest. Reche reported in 1910 that among the Matupi no girl who had not yet arrived at the age of seventeen had menstruated.

From Hogbin's account it is clear that among the Dap of Wogeo despite frequent intercourse from menarche onwards a girl does not normally conceive until several years have elapsed; not even when she marries early. Among this people there can be no objection to a recently married woman giving birth to a child, but this is so unusual a phenomenon that it has given rise to the belief that it is not a normal thing for a young adolescent married woman to be able to bear children, and certainly not normal in an unmarried woman. In this belief these natives show themselves far in advance of the Western world, for their belief reflects the possession of knowledge based upon observation which, owing to a fortunate pattern of conditions which does not exist among ourselves, enabled them to arrive at a knowledge of facts which were not understood elsewhere in the world until quite recently.

McLaren (76), who from 1911 to 1919 lived among the Australian blacks at Simpson's Bay, Cape York, in an extraordinarily interesting book recounting his experiences, quite in passing makes the following remarks:

> Freely and without concealment the unmarried girls gave themselves to the young men of the tribe and to visitors from other tribes, sometimes in exchange for a coveted article of ornament or use, but oftener because such acts were to them as natural as eating or sleeping.
>
> . . . But because of their knowledge of the abortive qualities of herbs and the like, illegitimate children were extremely rare. In all my eight years at Cape York they happened only twice, and in each case the girls were saved from being speared to death by the fact that their babies were born dead and undeveloped.

Finally Harrisson in a recent book about the natives of the New Hebrides notes of the North-West Malekulese: "Very rarely a child is born to an unmarried woman. Girls are married young." (50)

Such reports (see also those given in subsequent pages) raise a number of questions. What can be the explanation of this apparent infertility of the adolescent female in these simpler societies? Surreptitious abortion possibly, which escapes the inquiring attention of the anthropologist? This is possible, but there is absolutely no evidence that any of the infertile girls of these societies ever resorted to such a practice. Contraception? Clearly not among the Trobriand Islanders who have no understanding of the relation between intercourse and conception. And what of the abortive properties of the herbs used by the people described by McLaren, and the contraceptive properties of those used by the Eddystone Islanders described by Rivers? The evidence has recently been carefully examined by Himes and it

is his considered opinion that none of those herbs which have thus far been investigated for such properties can possibly have the effect which has been attributed to them (57). Early and indefatigable sexual life? There is no evidence that early and indefatigable sexual life produces a condition of adolescent sterility. On the other hand, the evidence available for those simpler peoples among whom sexual life commences at a very early age shows that they are neither more nor less sterile than those peoples among whom sexual life is begun late. It is to be remembered that Hogbin's natives did not commence active sexual life until they were seventeen years of age, yet they remained sterile for several years thereafter. It would indeed be very surprising to discover both licentiousness and abstinence producing the same effect. Free mixing of lovers? It has been said that prostitutes are sterile because they mix their lovers so often. But are prostitutes sterile? Or perhaps it may be more justly inquired: Are they sterile for this reason? Their fertility is without doubt low, but this is surely due, among other things, to the preventive measures which they take, and to the injurious effects of venereal and other disease from which they so frequently suffer. What other explanation then can there be for the infertility of these promiscuous adolescent girls? Is the adolescent infertility of these girls due to a natural or normal state of relative sterility characteristic of all normal human females at this period of their development, and perhaps also of all adolescent animals? Or is the phenomenon merely limited to the adolescent females of simpler societies? Finally, is it not possible that the phenomenon is a purely specious one?

To return an answer to these questions is the purpose of the present paper.

Certain terms which will be frequently used in the following pages may be conveniently defined here according to the definitions adopted by the Population Association of America (4):

Fecundity: The physiological capacity to participate in reproduction.
Sterility (or infecundity): The lack of physiological capacity to participate in reproduction.
Fecund: Having fecundity.
Sterile (or Infecund): Lacking fecundity.
Fertility: Fecundity expressed in performance and therefore measurable.
Infertility: Absence of fertility; synonymous with childlessness.
Fertile: Expressing fertility.
Infertile: Manifesting infertility; synonymous with childless.

LOWER MAMMALS

In an experiment reported in 1930 by Mirskaia and Crew (80) on 100 female mice which were mated at first oestrous, pregnancy followed in only 24 cases; 11 pregnancies occurring among the 58 coloured (19.5 per cent) and 13 among the 42 albino (30.9 per cent) mice. When, however, these same mice were three to six months old they exhibited a fertility ratio, i.e. the percentage of pregnancies following matings, of 80–90 per cent. Yet at first oestrous, or puberty, only 24 per cent of matings resulted in pregnancy.

Puberty in the mouse is defined by Mirskaia and Crew as "that stage of individual development characterized by the ability to elaborate functional gametes, and by the physical ability to, and desire to, play the appropriate rôle in mating" (81).

The authors write further:

"A review of the facts presented in this paper permits us to attempt a definition of maturity. It is manifest that puberty does not imply maturity of the individual, for when puberty is attained, neither the sex equipment nor the individual are full grown. We suggest that maturity is that stage of individual development which is characterised by the exhibition

of the maximum fertility ratio with reference to the conditions of husbandry that are present, and in the case of the female by the ability to produce viable offspring and to rear them. Litter size is not a criterion of maturity, for though it can be shown that in a population litter size increases with the chronological order of the pregnancy up to a maximum, it is as possible to obtain a litter of nine in a pregnancy following a first oestrous as to obtain a litter of two in a six months old animal. In our stock maturity is reached by the 3rd month of life.

"Puberty marks the completion of those processes of development which equip the individual for fruitful mating; maturity marks the completion of those processes of development which equip the individual for efficient reproduction. The two are distinct in time, for puberty is reached long before maturity is attained. This being so it can be understood that pregnancy is possible at and after the first oestrous, but that before maturity is reached such pregnancy will commonly be fruitless or dangerous. It is only when maturity is reached that pregnancy is uneventful. The causes of different rates of development leading to puberty and maturity respectively, and exhibited by different individuals, remains to be determined. It is seen from the tables that some individuals are mature at the time of puberty whilst others do not attain maturity until long afterwards" (p. 58).

These observations are worth discussing here in some detail.

In the first place it is to be noted that the number of pregnancies following upon first mating at the first oestrous exceeded by 11.4 per cent in the albino mice the number of pregnancies in the coloured mice. No explanation is offered by the authors for this phenomenon. Since the nutritional and environmental factors were the same for both breeds of mice, the suggestion is ventured that a genetic difference in the rate of development of the two breeds is probably responsible for the difference in the expression of fecundity; the albino reaching a higher fecundity potential at first oestrous than the coloured mice. This seems likely enough, but the suggestion requires to be experimentally tested. There is every reason to believe that the rates of development of an organ or system of organs of an animal are genetically determined, and that under similar, or even dissimilar conditions (within certain limits), animals of the same genetic stock will generally each develop at similar rates. There is also good reason to believe that genetically related animals of differing genetic constitution, living under similar conditions, will maintain their own independent rates of development (9, 125, 126). We need not go to lower mammals to prove this statement, but need only refer to the differences in the rates of development of various parts of the body in Negroes and whites living in the United States (22, 56). It is possible that the maturation rates of the various glands and organs subserving the functions of reproduction likewise differ in groups of differing genetic endowment. This is a suggestion; it is not intended to be more. As far as the human species is concerned there are a vast number of complicating variables which must be taken into consideration in any discussion of so-called racial fecundity potentials; such factors have recently been cogently discussed by Pearl (94).

In groups of mice such as those reported upon by Mirskaia and Crew all extraneous factors were constant; the only variables not constant being presumably the intrinsic ones of difference in genetic constitution. The available evidence very strongly suggests a connectioe here between the probable genetic diffnrence and the difference in the development of reproductive capacity (24). It is, however, quite possible that other variables may be involved, but upon the nature of these it is unnecessary to descant here; what appears to be likely is that the development of reproductive capacity is genetically determined, but capable of modification by environmental factors, such, for example, as light and temperature (15, 78).

The capacity for efficient reproduction in Mirskaia and Crew's mice was reached by the third month of life, and between this period and the age of six months pregnancies followed matings in these animals in from 80 to 90 per cent of cases. The age at first oestrous of these mice was, coloured 53 days and albinos 34 days. Hence, we may infer an adolescent sterility interval in these mice of some 30 days or so. But as the authors make clear in this study, at least 24 per cent of the animals were fertile upon first mating at oestrous. This is an observation of some importance. Differences in the rates of development leading to puberty and maturity in different individuals, so resulting that some are practically mature at puberty and others not until long afterwards, are the sort of differences which indicate the kind of variation that there is very good presumptive evidence to believe is characteristic of all animals unexceptionally. It is a matter to which we shall have occasion to refer more than once in the following discussions. From Mirskaia and Crew's observations then we may draw the following conclusions:

During puberty their mice were capable of mating, but that of such matings only 24 per cent of conceptions resulted, more than three-fourths of the matings remaining sterile, and thus strongly suggesting the existence of a normal adolescent sterility interval in more than three-fourths of the animals.

With reference to the mice of Mirskaia and Crew we may then define adolescent sterility as *the interval of time from first oestrous during which, in a given population of mice, a majority of normally developing mice are incapable of conceiving and remain functionally sterile.*

This definition renders it clear that not all mice are functionally sterile at first oestrous, but that a majority are. It is probable that the terms of this definition hold good for all mammals.

As Mirskaia and Crew have shown, not only are 76 per cent of mice sterile at first oestrous, but of the 24 per cent that do conceive 7, or 29.1 per cent, died at or immediately following parturition, while in addition four of the albinos ate their young on the day of birth; such animals as the latter usually dying shortly after devouring their offspring. These figures yield a death rate for first oestrous mothers of 45.8 per cent, a figure extremely and significantly high.

These two facts taken together, namely, the rarity of pregnancy at first oestrous and the high maternal mortality rate among those animals who do conceive at first oestrous, suggest a natural or developmental unreadiness of the female organism for the processes of reproduction at as well as shortly after first oestrous. In this respect, as we shall later have occasion to observe, the evidence for the human species likewise points in a similar direction. As Mirskaia and Crew write, "not only is pregnancy rare at the time of puberty, but it is also dangerous."

In explanation of the uncommonness of pregnancy following mating at first oestrous Mirskaia and Crew have suggested that it is reasonable to assume that "it is because the individual body as a whole is not yet physically fitted for the task though the sex equipment is." In a subsequent passage they write "It is manifest that puberty does not imply maturity of the individual, for when puberty is attained, neither the sex equipment nor the individual are full grown." That is to say, in the mouse the sex equipment though not full grown at puberty is fitted to carry out the processes of reproduction, though the body as a whole is not fitted to support the viable termination of such processes. Mirskaia and Crew have been

able to confirm these conclusions experimentally by provoking precocious maturity of the sexual system of the immature mouse by the injection of pregnancy urine, without producing any associated maturation of the whole body. Coitus in the case of such animals was not followed by pregnancy until the stage at which the first litter is normally produced (81).

As further evidence corroborating the fact of the reproductive unpreparedness of pubertal mice may be cited the same authors' findings that in primiparae suckling their young the pregnancy rate was only 24.1 per cent as compared with 50.0 per cent for nursing multiparae. The difference, according to these investigators, was not due to differences in incidence of ovulation associated with postpartum oestrous, but, they suggest, to a difference between pubertal and adult groups in the level of somatic activity necessary for full reproductive functioning (82).

The differences in the rates of growth of various organs and organ-systems of the body, and in their growth in relation to one another, is a subject which has only within comparatively recent years begun to receive some attention, so that our knowledge concerning these matters is still in a fairly primitive state; nevertheless it has long been obvious that the growth of the animal body presents a rather complex pattern of relative growth. Each organ and the system of which it is an integral part presents its own peculiar growth pattern, and each of these organs and systems in turn present growth functions in relation to one another of varying though definite kinds (20, 123, 61). It is unnecessary here to anticipate our later discussions of this subject, but it may be of service for the clearer understanding of what is to follow to note here that in all animals which have thus far been studied, and especially in man, a process of rapid growth of the gonads is initiated during puberty, and that in a relatively short space of time during the period of adolescence they reach almost their adult size (62). In the female the musculature (16) and the form and size of the uterus undergo a rapid series of differentiations, approximating almost to the adult condition (46, 109). Such post-pubertal changes in the development of the sexual equipment are chiefly structural. Physiologically the differentiation of the sexual system, most importantly the activities of the glands associated with it, the pituitary and the ovary, proceeds at a much slower pace (27, 93), and it is not until the functions of the latter are properly established that effective reproduction becomes possible. It appears that at puberty the pituitary elaborates a hormone which at first serves chiefly to stimulate the growth of the "sexual equipment," and but slowly serves to initiate those changes in the ovaries which only after some time has elapsed become fully established. It is primarily in the sense of these qualifications that Mirskaia and Crew's statement that "at puberty the individual body as a whole is not yet physically fitted for the task [of reproduction] though the sex equipment is," is to be understood.

Additional support for these observations may be found in the experimental work of Engle (32) on the development of puberty and sexual maturity in mice.

Seventy-two immature mice ranging in age from between 17 and 20 days were the subjects of this experiment. Of these animals 63 were given implants of anterior pituitary lobe daily on three successive days, while in the remaining 11 animals the glands were implanted on the first, second, and fourth day of treatment. In every case the rupture of the vaginal plate occurred at the end of the third day or

during the fourth day. After the third day of treatment the mice were kept with vigorous mature males. This induced precocious rupturing of the vaginal plate, which in normal mice ruptures at about the thirty-fifth day, and was followed by induced first oestrous from one to five days later. Thirty-seven animals mated during this first oestrous. From one to five days after mating 30 of these animals were autopsied. The results were exceedingly interesting.

"Eleven, or slightly more than one-third, were found to have ovulated. In some cases where 2 or 3 days had elapsed before autopsy no eggs were to be found, the tube being full of detritus as in unmated animals killed after ovulation. In these cases the corpora [lutea] were carefully examined, and corpora with retained ova were not found in numbers greater than occurs in normal animals. In other cases 15 to 20 morulae or blastocysts were counted in one tube or uterine horn and checked against the number of corpora lutea. In all cases there was considerable discrepancy, showing that many eggs either had not been fertilized or had degenerated following fertilization. Many of these developing eggs had been fertilized but at the time of examination were beginning to fragment. On the other hand there were found in animals killed at the appropriate stages, many morulae in the tubes, and blastocyst stages within the uterine lumen, which were, so far as could be decided, quite normal, yet none were implanted.

"Of the 5 animals which had been mated more than once, 3 did not ovulate. Seven animals mated on the 1st to 5th day after establishment of the vaginal orifice, but were not sacrificed. If any eggs were fertilized following mating, no animal gave a positive pregnancy sign on the 12th, 13th or 14th days, as is constant in pregnant mice" (p. 409).

These observations fairly conclusively prove that while ovulation may be prematurely induced in the immature mouse by anterior pituitary implants, and fertilization of such ova produced followed by development to morula or blastocyst stage, *implantation does not occur*, presumably owing to the absence of the sufficient anterior pituitary hormone which must first act upon the corpus luteum. Even in the animal in which oestrous has been precociously induced, the essential remainder of the body is quite unprepared for the function of reproduction.

In the light of these observations Engle makes the point that since these animals cannot be considered sexually mature the term "precocious sexual maturity" cannot justly be used to describe the condition induced in them.

Engle's study of the growth of the ovarian follicle in pre-pubertal mice, in which two distinct phases of growth are noted, from birth to the twelfth day, and from the twelfth day to puberty at the thirty-seventh day, is of interest here as exhibiting the gradual development of the morphological bases for reproduction. On the twelfth day the antrum folliculi is first seen. On the thirteenth and fourteenth days this is slightly augmented, while on the fifteenth day there is a considerable increase in the size of the antral cavity, almost to the average size of the follicle at first oestrous. "From the 15th day to the first oestrous the growth of the follicle has quantitatively no important growth change. What changes do occur are those of tissue differentiation" (33).

It was shown in 1930 by MacDowell *et al.* (70) that the 15th day is a crucial period in the life of the mouse.

Engle draws the following conclusions:

"These studies on the ovarian follicle in the 20 days immediately preceding oestrus, indicate that these large follicles must be secreting—and liberating—certain amounts of oestrin from the 15th day of life, and again emphasize the fact that puberty is a process of slow development, in which the first oestrus or first menstruation is merely an incident, expressive of a cumulative action of a delicate hormone balance in the organism. Since the follicles have attained nearly their full size in less than half the life span before puberty, it is clear that the changes occurring, which cannot be morphologically detected, must be those of slow physiological maturation of the organs

which operating satisfactorily together, constitute the living animal" (33).

And again:

"It is evident that while the interaction of the gonads and the anterior lobe affords the physiological mechanism for the first cycle as for the rhythmically succeeding ones, it is evident that this in turn is influenced by somatic factors, and that a general somatic maturity, as well as genital maturity, is essential to a complete reproductive potential" (p. 418).

In this respect Engle's work constitutes an independent confirmation of Mirskaia and Crew's work on genital maturity and somatic immaturity (81). It is worth noting that Engle considers the rupture of the vaginal plate, the first oestrous, the first ovulation, and the first mating in the mouse as constituting the several phases of the period of puberty (p. 406).

The first phase of puberty in the mouse occurs overtly as rupture of the vaginal plate, followed by oestrous some 48 hours later,—an event which in not more than a third of animals is synchronous with ovulation,—and by mating shortly thereafter. It would seem, however, that since first ovulation occurs synchronously with the first oestrous in slightly more than a third of cases, that it would be better to define puberty according to the various manifestations as they appear in the majority of mice, and perhaps to put ovulation after the first mating. The lag between oestrous and first copulation is generally only a few days, and in the majority of animals ovulation will normally follow during the next cycles after this. Since it is during these latter cycles that pregnancies occur in a significantly large proportion of cases as compared with matings at first oestrous, it would appear reasonable to regard the first ovulation occurring synchronously with first oestrous as a precocious development viably unsatisfactory, and to view those cases in which first ovulation occurs at an appreciable interval after first oestrous as the more normal condition. In both cases, in any event, it would seem that first ovulation is properly to be regarded as a phase of puberty and not of maturity; maturity being perhaps more correctly regarded as that stage at which the reproductive system is at a level of development which enables it to perform the functions of reproduction in a viable and efficient manner.

Quite recently Mills and Ogle (78) in the course of a discussion of adolescent sterility in man in which they cite evidence which they consider to support the existence of an adolescent sterility period in the human species, stated that such evidence would not be considered conclusive "without corroboration on experimental animals under controlled conditions. We have no records of timing of intercourse in . . . human cases . . . hence much of the discussion must remain problematical. It so happens, however, that animals give definite evidence of this same adolescent period of sterility . . ." The experimental animals referred to being white mice.

The suggestion that the findings on mice may be used to "corroborate" the existence of an adolescent sterility period in man and render the evidence for such a period in man conclusive, is open to some question. Mice and men are two very different systems of variables, and sequences of facts observed in connexion with the one cannot be generalized to hold good for the other. The most that can be said here is that since mice and men are mammals, and since in a general way their bodies grow and function in a similar manner it is possible that, allowing for all the differences in rates of growth and development *et cetera*, a similar infecundity period characterizes the early adolescent human individual. As Hartman (51) puts

it, "what is phylogentically significant is apt to be physiologically fundamental."

Such a possibility would be tantamount to a guess were it not for the fact that in all the animals so far investigated the facts all point in the same direction. It is, however, one thing to speak in terms of possibility, and quite another to speak of "corroboration" and the rendering "conclusive" of evidence projected from one distinctive group to the uncertain evidence of another very different one.

The evidence which Mills and Ogle's study corroborates and renders conclusive is that of Mirskaia and Crew (80, 81), although they do not refer to the work of the latter investigators.

Mills and Ogle were interested in the relation between climate and the onset of menarche, and in the effect of climate upon the fertility of man; in order to learn something of the nature of this relation they resorted to white mice as their experimental animals. The account of their experiment and their results is best set out in their own words:

"Mice, grown from a single stock, were divided into four groups. One group was kept in the control breeding room at 70–80°F., another was placed in a special room kept at 64–68°F., and a third placed in a hot room kept at 88–92°F. and about 70 per cent relative humidity. A fourth group was shifted daily between the hot and cold rooms, spending 12–16 hours of each day in the moist heat. In every case pregnant mothers were allowed to deliver their young in the control room and kept there with the litter until the young were 21 days old. This was necessitated by the fact that the mothers usually kill the young if left in either the heat or cold.

"From Table 1 we see the first oestrus, corresponding to the human menarche, beginning at 33 days of age in the control room group, at 36 days for the young of control room mothers placed in the cold room at 20 days of age, at 33 days for the cold room young of cold room mothers, and at 35 days for the young of control room mothers shifted daily from hot to cold. Young placed in the moist heat, however, show a definite and striking delay in the age of first oestrus. Young of control room mothers, placed in the heat at 20 days of age, began the oestrus at 37 days of age, but the young of the hot room mothers were delayed to *46 days*, confirming our earlier statements on the later menarchial age for girls of native tropical stock," (pp. 612–613).

TABLE 1*

First oestrous and first delivery data on white mice

DESCRIPTION OF GROUP	NO. OF CASES	AVERAGE FIRST OESTROUS (*days*)	AGE AT FIRST DELIVERY (*days*)	LAG IN FERTILITY FIRST OESTROUS TO FIRST CONCEPTION (*days*)
Breeding room controls	20	33	84	31
Cold room immigrants	11	36	88	32
Cold room descendants	25	33	79	26
Hot room immigrants	31	37	94	37
Hot room descendants	9	46	..	..
Change group immigrants	26	35	138	83

* After Table 4 Mills and Ogle.

From these observations the following facts emerge:

(1) Only 5 per cent of each of the groups of mice conceived at each of the first three oestrous periods, and it was not until the 6th and 7th oestrous periods that full fecundity was established. (2) The earlier the appearance of the first oestrous, the longer was the lag in fertility. (3) The later the appearance of oestrous, the shorter was the absolute lag in fertility. (4) The average lag in fertility for three normal control groups of mice was 31.8 days. (5) Stimulating cold produced a quickening in sexual development. (6) Moist heat produced a depression and a

slower development of the sexual functions, and an increase in the fertility lag. (7) Great temperature variability produced a marked suppression of fertility.

We may conclude, then, from the work both of Mirskaia and Crew and of Mills and Ogle on different stocks of mice under very different conditions, that the majority of mice are characterized by an adolescent sterility period of some 31.8 ± 1.9 days.

THE RHESUS MONKEY

The next group of animals which has been the subject of investigations which can be safely utilized in discussing the question of adolescent sterility is represented by the rhesus monkey (*Macacus* sive *Pithecus rhesus*). These investigations were carried out by C. G. Hartman on the Carnegie colony of animals at Baltimore and first briefly reported in 1931 (52). In this communication Hartman adduced evidence to show that the generally accepted belief that puberty and maturity or reproductive capacity are synonymous or synchronous phases of development is erroneous. From his examination of the evidence Hartman was led to the conclusion that the interval of time which normally elapses between puberty and maturity in man, monkey, and rat "is about what one would expect with the application of Donaldson's law of equivalent ages: three years, one year and one month, respectively, for man, monkey and rat" (p. 226).

Reporting his findings on fifteen rhesus monkeys whose every menstrual cycle had from its inception been carefully observed, Hartman writes:

> "these fifteen females averaged 3,350 grams in weight at the first menses. Most of them were mated soon after puberty, but not a single female conceived before attaining a weight of 4,370 grams. The average weight at first conception of nine of these females was 5,000 grams hence it; is apparent that many menstrual cycles passed between the first menses and the first conception, despite frequent matings in the interval. The interval may be estimated at about a year of time" (p. 226).

In these young animals Hartman found that "the menstrual cycles of the young females are extremely irregular in length and duration, and there is a very slow incidence of ovulatory as compared with non-ovulatory cycles" (p. 226).

In his monograph on the reproduction of the rhesus monkey published in 1932 Hartman (53) makes it quite clear that the failure to ovulate is "the probable cause of the relative sterility of adolescent females" (p. 23).

In his earlier communication (52) Hartman went on to suggest that similar conditions characterize the human female, and that although the mores of a given people may force effective marriage upon the girl at her first menstruation, "there is much indication that, by and large, nature herself prevents motherhood supervening during an important series of preparatory years" (p. 226). The greater part of the communication is, in fact, devoted to the establishment of a case for the existence of a period of relative sterility in the adolescent human female, the concluding statement of which is to the effect that "It seems highly reasonable that Malinowsky's (*sic*) predicament is explained by the facts presented in this paper, namely, that the first menstruation (*puberty*) marks merely an early manifestation of a train of events (*adolescence*) which only after three or four years on the average lead to ovulation and conception, the proof of *maturity*" (p. 227).

From Hartman's observations on the rhesus monkey it is very clear that in this animal the development of sexual maturity is a very gradual process; a function of growth, prior to the completion of which

the animal remains functionally sterile, about one year of time elapsing from the appearance of the first menstruation before the animal is able to conceive. Hartman (53) writes:

"it appears that the average age of the rhesus female at first conception is pretty nearly 5,000 grams, which, although the number is still small, [a total of 9 available records of conception and 15 of menstruation], nevertheless definitely points to a considerable period of adolescent sterility, inasmuch as practically the same opportunity for insemination was afforded before the first conception as after.

"A similar relative sterility, I am convinced, also occurs in very young girls" (p. 24).

Hartman points out that the terms adolescence, puberty, and maturity are often used loosely and interchangeably, and for the purposes of his own study defines these terms as follows:

"*Puberty* is used synonymously with the menarche, that is, the time of the first menstruation; *maturity*, the age of the first ovulation and the first uterine preparation for pregnancy; *adolescence*, the two periods combined, that is, the entire period when reproductive functions are in the process of attaining the climax, reproductive capacity, namely, ovulation, fertilization, implantation. For there is reason to believe that adolescence is not a sudden but a gradual change in the life of the individual mammal and that in primates the first ovulation is separated by months and perhaps years from the first menstruation.

"Some observations on the monkeys of the Carnegie Colony have led to these conclusions. In the first place no adolescent female has conceived during the first two years after puberty. Furthermore, there is a very high incidence of non-ovulatory cycles in young animals. These observations point to the failure to ovulate as the probable cause of the relative sterility of adolescent females" (45, p. 23).

It will be recalled that in his earlier communication Hartman (52) gave the interval between menstruation and first conception in his rhesus monkeys as "about a year of time" (p. 226). In his 1932 monograph (53) he states that "no adolescent female has conceived during the first two years after puberty" (p. 23). A careful study of Hartman's protocols indicates that the first estimate of about one year is the correct one, and in a personal communication Dr. Hartman has been kind enough to confirm this.

In summarizing the evidence Hartman (53) concludes:

"adolescence is a period of endocrine instability, as evidenced by irregular menstruation, preponderance of menstruation without ovulation, follicular atresia, excessive swelling of the sex skin, comparative sterility. The sterility of adolescence is due to failure to ovulate. This, of course, entails a failure of the uterus to undergo the pregravid changes in preparation for the reception of an egg. It is highly probable that the uterus 'learns' to undergo these changes in a step-like fashion, the organ growing a little larger with each succeeding cycle in which the ovary likewise produces a larger and larger follicle until this no longer degenerates but goes 'over the top' and ovulation occurs" (p. 26).

THE CHIMPANZEE

The only other animal for which a certain amount of reliable information is available with reference to the problem of adolescent sterility is fortunately a close relative of man, namely, the chimpanzee.

Tinklepaugh (125) reported in 1933 a chimpanzee, Dwina, in whom the first menstrual bleeding was observed when she was at an estimated age of 9 years. The first swelling of the sex skin had appeared 5 months previously and there were four cycles of sex swelling before the establishment of menarche. Dwina was continuously caged with a mature male but conception did not take place until four months after the first menstruation. The sterility interval in this animal then was only four months. It is of interest here to note that this mother died 15 days after giving birth. She may have died of puerperal septicemia, or from the inability to withstand the strain upon her system. Recalling the fate of early conceiving mice it would look as if Dwina had possibly

conceived too early in her development for her own good, and in this respect her history would correspond to the early-conceiving mice of Mirskaia and Crew, almost half of whom either died or ate their young. This is rendered all the more probable when we consider the following two well-authenticated cases.

Yerkes (137) reported in 1935 on a second-generation captive-born chimpanzee, Cuba, as follows: "She first exhibited characteristic genital swelling [oedema of the sex skin] in April 1933. Menstrual bleeding occurred first on July 10, 1933, when she was seven years, four months, old. She was caged with a mature male from May, 1933, and she became pregnant August 9 (± 5 days), 1934, at the age of eight years, five months" (pp. 542–543).

The sterility interval in this chimpanzee was then one year and one month. It is further to be noted that in this case parturition, which occurred on April 11th, 1935, was uneventful and that the mother and infant both did well, the infant weighing close to four pounds at birth.

"Mother and infant were observed continuously from 3:20 to 4:10 P.M., and both verbal and pictorial records were made of their behavior. As primiparous mother Cuba exhibited behavioral inadequacies. Although from the first she carried Peter about with her, holding him awkwardly, usually grasped in one hand, she did not, according to species practice, place him upon her abdomen or breast and permit him to cling to her. Instead she treated him much as she might any strange object which interested, puzzled and annoyed her. Toward the end of the period of observation she forcibly broke his hold upon her whenever he succeeded in grasping her hair or skin with hand or foot. Often in so doing she was rough and impatient and vocalized complainingly.

"Peter was left with his mother for about eighteen hours (overnight) under intermittent observation. As Cuba did not accept him, to be nursed and generally cared for, it was necessary to take him from her, in order that he might not become the victim of her inexperience, curiosity, neglect or abuse" (pp. 542–543).

One may well raise the question whether it is possible that these behavioral inadequacies are in some significant way, apart from the factor of experience, associated with the degree of reproductive maturation of the animal? Or is the factor of experience perhaps the important thing here? (132, 139).

In connexion with Cuba Dr. J. H. Elder informs me that this animal has exhibited somewhat similar behavior with her second infant; although she kept it by her she did not, however, care for it in a satistory manner, so that after some seven weeks it had to be taken from her because of serious undernourishment.

In the Johns Hopkins chimpanzee, Evo, reported in 1935 by Schultz and Snyder (111)

"the sex skin became oedematous for the first time when she possessed all her permanent teeth except the third molars, and at the carefully estimated age of 9 years and 1 month. . . . This swelling persisted for nearly 8 months, *i.e.*, until a few days before her first menstruation" (p. 194).

"The first menstruation of Evo occurred at the estimated age of 9 years and 9 months, and 9 months before the eruption of the lower third molars" (p. 195).

Evo was continuously together with a mature male, Dayton, from an early age, although intercourse did not take place until after her 7th menstrual cycle, or approximately 8 months after her first menstruation, when after

"coitus between the two was continued fairly regularly 3 and more times daily for approximately 6 months or for several weeks after she became pregnant" (p. 197).

". . . . in spite of regular menstruation on the part of the female and abundant coitus on the part of both sexes, no conception took place for a considerable time, namely, for at least 5 months after the first possible exposure and until after the 11th menstrual period, which occurred exactly 1 year after the first menstruation. Evo's estimated age at the time of conception was 10 years and 9 months, or 3

months after her lower third molars had appeared, and about 8 months before her permanent dentition became completed by the eruption of the upper third molars" (pp. 197–198).

It appears then that in Evo the sterility interval lasted for one year. On the 188th day (after the onset of the last menstruation) Evo's health changed for the worse, and on the 196th day of pregnancy she spontaneously aborted a still-born fetus. She subsequently made a good recovery.

Here, once more, is the case of a first pregnancy in an adolescent chimpanzee which terminated unsuccessfully, and again we see here the suggestion that pregnancy in the immature animal is a dangerous process, which will frequently tend to end fatally either for the mother or offspring or both. We may recall here McLaren's report of the only two native girls who in all his eight years at Cape York were alone in giving birth to children before they were married, their offspring being still-born and undeveloped (76).

Concerning the two other chimpanzees in the Johns Hopkins colony the authors write:

"In the second female Hopkins chimpanzee, Mae, the first sex swelling appeared at a dental age closely corresponding to that in Evo, [*i.e.*, about 9 years and 1 month], but, in contrast to that in Evo, this swelling lasted for only about 3 weeks, and has not reappeared at the time of writing, about 5 weeks later. In the third female Hopkins chimpanzee, Pandora, the sex swelling had made its first appearance before the permanent canines had erupted and persisted very pronouncedly for approximately 14 months. Neither Mae nor Pandora has as yet menstruated" (p. 194).

The authors do not tell us whether Mae was ever exposed to Dayton, the mature male, but they state that at "About the time of Evo's first menstruation the younger Hopkins female, Pandora, was added to the colony. Dayton had regular and frequent sexual intercourse with Pandora from the start, even though she never menstruated but showed merely pronounced sex swelling throughout the period from her arrival to the present" (p. 197).

Dr. J. H. Elder has recently (14.2. '38) very kindly supplied the writer with data concerning the reproductive history of the chimpanzee, Soda, which has been under observation for some years at the Yale Laboratories of Primate Biology, Florida. Beginning about the first of June, 1935, at an estimated age of 7 years 11 months Soda showed very slight enlargement of the external genitalia, which persisted with almost imperceptible variations until August 19, when it disappeared entirely. The swelling began again on September 22, and this time resembled more closely the typical swelling, although at this time it was still much smaller than those exhibited later. First menstruation occurred November 18, 1935 at an estimated age of 8 years 4½ months. Conception occurred on the 19th day of the seventh cycle, on or about September 11, 1936. Since, however, there were only four opportunities for conception in the cycles previous to the seventh, it is not possible to say with certainty that this animal did not ovulate, or was incapable of conception, before the seventh cycle. But since on these four previous occasions she was mated with a mature male at the optimum mid-interval period for conception, there is a good probability that she had not previously ovulated, or at least, that she was not previously capable of conception. The menarche-conception interval in this case may then tentatively be said to have been 10 months.

From histories such as those given above it seems probable that the chimpanzee is

normally incapable of conceiving until some appreciable time after the establishment of menarche.

Two additional records of uncertain value may be noted here.

Fox (38) in an extremely interesting paper, written in 1929 on births observed in two anthropoid apes, reported on a chimpanzee, Marianne, who had come to the Philadelphia Zoo in 1924 when she was estimated to be about 3 years old. She first began to menstruate in 1926 at the age of five years, but it was not until she was seven and a half years old that conception took place. During the intervals between menarche and conception she was caged with a male chimpanzee of her own age. Schultz and Snyder state that "a male was not continuously present during this time" (99, p. 198), but this is not so according to Fox. Intercourse, according to him, took place frequently between the animals during this period. In a personal communication (15. 3. '38) Dr. Fox writes

> "The companionship in the same cage of the male and female chimpanzee was uninterrupted from menarche to conception. That is what can be read from my article of 1929. . . . They came together and grew up together. There is no reason to think that any period of time passed when they were separated so that from the institution of menstruation of the female chimpanzee until conception the two must have experienced the same physiological development of sexual maturation together and each under the influence of the other.

Since the somewhat younger male may have been in process of maturing during a part of the time when the female had already attained to reproductive capacity, it is difficult to draw any definite conclusion from this case.

Similarly for the chimpanzee Boo-Boo of the London Zoological Gardens, reported by Wyatt and Vevers (136), the evidence is not quite clear. Boo-Boo first menstruated at an estimated age of 8 years in 1931. She was not, however, put together with a mature male until three years later in June 1934, whereupon she promptly conceived, being at an estimated age of 11 years at the time of conception.

These various observations on the chimpanzee yield four cases in which the conditions necessary to enable one to make a fairly satisfactory judgment concerning the existence or not of a period of adolescent sterility in the chimpanzee have been more or less adequately fulfilled. These cases tabulated according to each investigator's presentation of the data are summarized in Table 2.

Upon the basis of the evidence provided by these four cases it is possible to say that the degree of probability that the chimpanzee is normally characterized by a period of adolescent sterility is fairly high, for it is unlikely that it is purely due to accidental factors that in the only four cases for which we have reliable evidence the facts should all point the same way; and further, such evidence as is provided by the cases of Marianne and Boo-Boo, though not altogether satisfactory, negatively supports the existence of such a period of sterility in these particular animals, indicating in the latter case that when a sufficient length of time has elapsed following the appearance of menarche the animal is capable of conceiving promptly when put together with a mature male. In the case of Boo-Boo the conditions parallel those existing among human groups, where marriage and effective intercourse do not occur until a considerable interval after the establishment of menarche, when the promptitude with which conception follows intercourse obscures the possible existence of an adolescent sterility period in the human female.

It is necessary to be quite clear here con-

cerning the fact that with the exception of Yerkes' data all ages given for the animals referred to above are *estimated*. Schultz, who is our best authority on the estimation of the age of primates, may be relied upon to have given as nearly accurate an age for Evo as possible. Even so it is not unlikely that the age of this animal was somewhat less or more at menarche than the age estimated by Schultz. Dental age, as Schultz has himself shown (110), is not a reliable index of chronologic or even physiologic age. In the case of Dwina Schultz is of the opinion that she was less than 8 years of age at menarche (p. 502), rather than 9 years as estimated by Tinkelpaugh.

Marianne was probably 2 years older than the 5 years assigned to her by Fox at menarche; while Boo-Boo's estimated age of 8 years at menarche probably represents a near approximation to her true age.

Two other chimpanzees for which information is available concerning inception of sexual skin swelling and menstruation may be added to our number here. In the animal "S" at the London Zoological Gardens Zuckerman (141) noted sexual skin swelling for 2 years before menarche. In the animal Kani of the Department of Physiology at Yale University, Zuckerman and Fulton (144) observed the first sexual skin swelling when the animal was at an estimated age of 7 years; irregular fluctuations in the amount of swelling being noted during the subsequent years.

Arranging the data for first sexual skin swelling and menarche, as in Table 3, certain interesting facts are seen to emerge.

Since the ages given in Table 3 are with one exception all rather hazardous estimates, and the number of cases so small, it would be unwise to attempt any elaborate analysis of the findings there presented. Actually, we can at present say very little concerning the average age at which the reproductive functions make their appearance in the chimpanzee, but if we were forced to hazard a suggestion on the basis of such evidence as that cited above we should have to put the average age of the appearance of the first sexual skin at 8 ± 1 years, and age at menarche at 8 years 6 months ± 15 months. The sexual skin-menarche interval would thus be of 6 ± 3 months duration. It is of interest here to note that in a paper published in 1937 by Spence and Yerkes (120) on the Florida colony of chimpanzees the authors found that "the average age of seven animals (six of estimated age) at the time

TABLE 2

Developmental sexual history with especial reference to the adolescent sterility interval in the chimpanzee

OBSERVER	ANIMAL	FIRST SEXUAL SKIN (*date, age*)	SEXUAL SKIN SWELLINGS INCEPTION TO MENARCHE	MENARCHE (*date, age*)	FIRST CONCEPTION (*date, age*)	DELIVERY (*date, age*)	ADOLESCENT STERILITY INTERVAL
Tinklepaugh 1933	Dwina	May, 1929 8 yrs. 8 mos.	4	Sept. 8, 1929 9 yrs.	Jan. 8, 1930 9 yrs. 4 mos.	Sept. 11, 1930 10 yrs.	4 mos.
Yerkes 1935	Cuba	Apr., 1933 7 yrs. 1 mo.	3?	July 10, 1933 7 yrs. 4 mos.	Aug. 9, 1934 8 yrs. 5 mos.	Apr. 11, 1935 9 yrs. 1 mo.	1 yr. 1 mo.
Schultz and Snyder 1935	Evo	9 yrs. 1 mo.	Continuous until two weeks before menarche	9 yrs. 9 mos.	10 yrs. 9 mos.	—	1 yr. 0 mos.
Elder 1938	Soda	June 1, 1935 7 yrs. 11 mos.	2	Nov. 18, 1935 8 yrs. 4½ mos.	Sept. 11, 1936 9 yrs. 2½ mos.	May 5, 1937 10 yrs. 0 mos.	10 mos.

of the first menstruation was 8.0 years, the range being 7.25 to 8.33 years." (p. 242). As will be observed these figures are remarkably close to those which have been given above.

What is brought out fairly clearly in Table 3 is that there is a considerable amount of variation, in and as between different animals, in respect of the age of appearance of first sexual skin swelling, and in the duration of the interval between the first sexual skin swelling and menarche. The same holds true, as Schultz and Snyder (111) have shown, for the menstrual cycle. Such variability is, of course, to be expected, and the differences observed are probably to be ascribed to individual differences in rate or degree of development of the reproductive system; but this is a problem for future research to determine.

TABLE 3

The sexual skin in relation to menarche in the chimpanzee

OBSERVER	ANIMAL	AGE AT FIRST SEX SKIN	NUMBER OF SEX SKIN CYCLES PRIOR TO MENARCHE	AGE AT MENARCHE	INTERVAL BETWEEN FIRST SEX SKIN AND MENARCHE
Fox 1929	Marianne	?	?	5 yrs.	?
Zuckerman 1930	"S"	?	?	?	2 yrs.
Tinklepaugh 1933	Dwina	8 yrs. 8 mos.	4	9 yrs.	4 mos.
Zuckerman and Fulton 1934	Kani	7 yrs.	8?	Never menstruated	—
Wyatt and Vevers 1935	Boo-Boo	?	?	8 yrs.	?
Yerkes 1935	Cuba	7 yrs. 1 mo.	3	7 yrs. 4 mos.	3 mos.
Schultz and Snyder 1935	Evo	9 yrs. 1 mo.	Continuous swelling for 8 months	9 yrs. 9 mos.	8 mos.
Schultz and Snyder 1935	Mae	9 yrs. 1 mo.	1 +?	5 weeks later sex swelling just reappeared; no menstruation	?
Schultz and Snyder 1935	Pandora	8 yrs. 6 mos.	Continuous swelling for 14 months	No menstruation	14 mos. +?
Elder 1938	Soda	7 yrs. 11 mos.	2	8 yrs. 4½ mos.	5½ mos.

The first sexual skin swelling of the chimpanzee is the outward sign of beginning reproductive maturation, the overt sign of the first phase of this process. In man such a pre-menarchial phase undoubtedly also occurs, but of this external evidences akin to those seen in the sexual skin of the chimpanzee have neither been sought for nor demonstrated. Although the fact is easily confirmed John Hunter (1748–1793) appears to have been the first (*ca.* 1787?) to have drawn attention to the changes in the pudendal skin color with pre-pubertal growth and during pregnancy in the human female. He writes: "The skin of the pudenda grows redder and redder to the years of puberty, and seems to have little or no rete mucosum. When a woman is with child these parts grow darker, even darker than the other skin, like the nipple; which colour does not terminate at once, but is gradually lost. This darkness extends to the 'nymphae' and 'carunculae myrtiformes'" (60).

Such changes, of course, reflect the activity of certain internal secretions, and it is probable that the sex hormones which are poured into the blood stream during the normal oestrous cycle of the human

female produce changes in the skin of the pudendal region which are related to the sexual skin phenomena of sub-human primates, although in man the well-known menstrual skin changes tend to be rather more diffuse (14) than localized (124). It is, however, quite possible that such changes are in the human female limited to the pubertal, pregnancy, and lactation periods. In this connexion it may be noted here that while in most of the Catarrhine primates in which the sexual skin has been reported the condition appears to be a cyclical phenomenon associated at first with beginning ovarian activity and eventually with imminent ovulation, it is, according to Hartman (53) in the rhesus monkey limited to the period of adolescence, and only rarely appears in the adult (p. 24). This observation has in 1938 been confirmed by Zuckerman (148), who has elsewhere (147) also stated that the rhesus monkey rarely experiences *marked* sexual skin swelling (p. 324). In 1938 Schultz (112) showed that sex skin swelling occurs in the Bornean orang, but this appears to be limited to the period of pregnancy. Sex skin phenomena such as occur in the chimpanzee have never been observed in any of the developing or mature gorillas which have been under observation in various zoological gardens. Raven (100), however, stated in 1936 that while trailing a group of mountain gorillas (*Gorilla beringei*) west of the southern end of Lake Kivu in the Belgian Congo, he saw, at a distance of some 40 yards, an apparently adult female: "The genital region of this individual was swollen, pale in color, and appeared to be tumid. I judged that the swelling was similar in size to that of a female chimpanzee during maximum enlargement, and thus proportionately smaller, considering the larger size of the gorilla" (p. 416). Then the animal disappeared from view. It may be that 40 yards is not a satisfactory distance at which to judge the state of the genital region of a departing gorilla; but anyone who has once seen the sexual skin swelling of a chimpanzee during its maximum enlargement would have very little difficulty in recognizing it at such a distance. Raven is an excellent observer with unrivalled field experience; his observation is therefore not to be lightly considered. The fact, however, remains, that no one has ever made a similar observation. The late Dr. C. V. Noback shortly before his death informed me that the post-pubertal gorilla (*Gorilla gorilla*), Janet Penserosa, at the New York Zoological Park, which he had had under more or less continuous observation since its infancy, although she had menstruated a number of times never exhibited any circum-anal skin changes, but that a "premenstrual" swelling of the labia majora occurs; that is, before each menstruation, according to Noback, there is a turgid swelling of the labia majora which ceases during menstruation and does not recur again until shortly before the next menstruation. This fact was briefly reported by Noback in 1936 (92). At his invitation I was able to confirm the presence of such a swelling on two separate occasions (March, and October, 1936), but I am unable to say exactly when these swellings occurred in relation to the oestrous cycle. Upon examination the labia majora were found to be distinctly tumid and remarkably soft to the touch, yielding easily upon light pressure. Their color was a glistening black, very distinguishable from the dry scaly gray-black color of the rest of the perineal region. It is quite possible that in respect of the sexual skin swelling there is a specific difference between *Gorilla beringei* and *Gorilla gorilla*. The sporadic distribution of the sexual

skin among the primates led Zuckerman (143) to suggest in 1933 that this character has developed independently among the different primates (p. 47).

In 1886 Hartmann (55) referred to "die meist farbrigen Zeichnungen der weiblichen Genitalen eines älteren Gorilla-Weibchens vor, welches, obgleich nur schlecht in Weingeist conserviert," but it is not certain whether this may be taken as evidence of the existence of a sexual skin in this animal, which was presumably of the species *gorilla*.

In the animal (*Gorilla gorilla*) Pussi which was at the Zoological Gardens of Breslau from September 3, 1897, when she was estimated to be 4 years of age, to the date of her death from chronic nephritis on October 6, 1904, though carefully sought for no evidences of menstruation (41) nor of swelling of the labia were ever observed. Zuckerman (143) states in 1933 that certain anatomical observations of Gerhardt in 1906 (40) seem to support the view that the gorilla shows sexual skin changes; but this must be an error for Gerhardt explicitly states that "Periodische Blutungen aus den Genitalen oder Schwellungen der Schamlippen, die sich sonst bei den erwachsenem Affen, und auch beim Schimpansen finden, sind hier nie aufgetreten" (p. 635). Nor did Director Grabowsky (41) ever observe such changes. Section of Pussi's ovaries revealed a total absence of ripe ova or any evidences of corpora lutea; only a few large follicles were present. Yet this animal, Gerhardt believes, was almost certainly not less than 11 or 12 years old (p. 634) at the time of its death.

I have calculated from the published data of Noback (90, 91, 92), that Janet Penserosa was 9 years and 7 months of age at the time (29. 3. '36) of her first observed menstruation, which is an estimate probably more near the true age of menarche in the gorilla than one would be led to believe from the conditions observed in Gerhardt's specimen.

In condition of genital swelling, and age at menarche, the gorilla would appear to resemble man more closely than the chimpanzee. But let us return to the chimpanzee.

Physiologically and developmentally the sexual skin swelling of the chimpanzee means that a gonadotropic hormone elaborated by the anterior lobe of the pituitary sufficient to produce maturation of the follicles in the ovaries, but generally insufficient to produce ovulation, stimulates the release of the follicular hormone oestrin which, among other things, produces an accumulation of intercellular fluid in the perineum (141, 142, 143, 144, 145, 146, 147, 148), the change thus produced being observable during the period of contrectation as the swelling of the sexual skin. It is here suggested that the first appearance of the sexual skin in primates is a phenomenon akin to the rupture of the vaginal plate in mice and rats, for the evidence indicates that the two events are fundamentally due to the operation of similar factors in the two groups of animals. In the guinea-pig the period immediately preceding the first oestrous, the proestrum, is marked by congestion and swelling of the external genitalia (63); the same holds true for dogs.

It is important to note here that in the chimpanzee Kani, reported by Zuckerman and Fulton (144), when, after a year of irregular sexual skin swelling without menstruation having yet appeared, the ovaries were removed and serially sectioned, it was found that none of the follicles was larger than 2 mm. in diameter, most being in process of atresia. No luteal tissue was anywhere observed, in-

dicating that follicular growth had never proceeded beyond this stage, and that ovulation had never occurred. Thus, after a year of sexual skin activity, towards the end of which, it may be mentioned, the animal was not in good health, Kani had neither menstruated nor ovulated. It is, of course, very unlikely that ovulation would *normally* ever occur before menstruation; it may be safely assumed that ovulation as a rule normally takes place at some time after the first oestrous or menarche.

Such local changes: rupture of the vaginal plate, oedema of the external genitalia, or sexual skin swelling, are clearly to be regarded as parallel stages falling into the period of puberty in the development of the reproductive functions; for it is fairly clear that at this stage of sexual development neither mouse, rat, guinea pig, nor chimpanzee is ready for normal reproduction.

Such changes represent the phenomena of the progress of reproductive maturation preceding the development of those processes which result in maturity, or the functional capacity to reproduce viably. Puberty, upon this view then, is the period of maturescence during which the organism undergoes a series of morphological and physiological changes upon the completion of which the organism is said to be reproductively mature. That is when the period of puberty may be said to terminate and the period of sexual maturity to begin, and as has been shown, during the period of puberty the organism appears to be relatively sterile.

With respect to the duration of the adolescent sterility interval in the four chimpanzees for whom the evidence is reasonably clear, we may note that this lasted for 13 months in Cuba, 12 months in Evo, 10 months in Soda, and 4 months in Dwina. Again, this is the sort of variability which one would expect. What the average duration of the sterility interval in the chimpanzee is we do not know, but it is probable that it is nearer the 13 months of Cuba than the 4 months of Dwina. No doubt, as in all the mammalian forms thus far surveyed, the chimpanzee is in a certain small proportion of cases capable of conceiving at or shortly after first oestrous; and this is probably true of all mammals including man, but such cases though perfectly normal are in the minority, and more often than not represent individuals who are biologically unprepared to carry out the processes of reproduction efficiently. The so-called adolescent sterility period is merely a measure of the chronologic time during which the organism is developing towards the attainment of a condition of *efficient* sexual status, that is, maturity. It is clear that this status is attained only gradually following the establishment of the first overt signs of puberty. Differences in the rates of development of different individuals will, of course, determine when in relation to puberty this status is reached in chronologic time. A perfect demonstration of this fact was provided in 1937 by Engle *et al.* (35) for first oestrous and growth rate in the rat.

In terms of physiologic time it is not difficult to understand that an animal may mature very rapidly after the appearance of the first oestrous and reach a physiological stage of maturity equal to that of an animal which has matured at an appreciably slower rate and is chronologically appreciably older at maturity. In chronologic time there will be a great difference in the duration of the sterility interval, in physiologic time there may be none. This may be stated both as a fact

and as an hypothesis to account for the observed differences among different animals in the interval elapsing between first oestrous or menarche and the development of efficient reproductive capacities.

The evidence for the mammals thus far surveyed if it does not prove at least very strongly suggests the existence in the majority of adolescent or immature animals of a condition of sexual immaturity during which the animal is incapable of reproduction. The duration of this condition of relative sterility, counting from the first oestrous, is of variable length in different animals, and is probably correlated with their individual rates of development.

(To be concluded)

BIOLOGICAL EFFECTS OF POPULATION DENSITY IN LOWER ORGANISMS (*Concluded*)

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2. DROSOPHILA

a. Culture

INFORMATION as to the general biology of *Drosophila* will be found summarized in Sturtevant (1921) and Morgan, Bridges, and Sturtevant (1925). *Drosophila* is ordinarily mentioned as a fruitfly since decaying fruit is its natural food, and large numbers of them always collect seemingly out of nowhere whenever a bit of over-ripe fruit is left exposed in warm weather. Northrop (1917a) found that they cannot be raised successfully on sterile banana, although decaying banana is an excellent medium. He was unable to raise them on a sterile mixture of pure protein, sugar, salts and fat but the larvae would grow on the kidney, liver, and pancreas tissue from a dog and on the dead bodies of flies themselves. They did quite well on yeast alone while the addition of banana, casein, or sugar to the yeast increased the percentages which were able to develop showing that these substances could be utilized to some degree by the flies as food. Baumberger (1919) found that by soaking eggs for 10 minutes in 85 percent alcohol he could sterilize them so that when they were placed on sterile food they would not inoculate it with yeast, mold, or bacteria. Keeping the medium sterile in this way, he found that *Drosophila* larvae do not grow well on sterile food but that bacteria and molds may take the place of yeast. A loose symbiosis exists between yeast and *Drosophila*, the yeast being spread by the flies which depend upon it to synthesize many non-protein nitrogenous compounds into proteins for themselves. Northrop (1926b) says, however, that by the proper choice of foods he has been able to raise *Drosophila* under aseptic conditions in the dark for 230 generations. *Drosophila* were ordinarily raised in the laboratory on decaying banana and later on banana agar seeded with yeast which was easier to handle. This, however, was a very variable food substance since it depended upon the ripeness and other qualities of the bananas which changed seasonally and could not be well controlled. For his quantitative experimental work, Pearl particularly desired a standard food which could be duplicated in precisely the same fashion at any time. After trying a number of mixtures, Pearl and Penniman (1926) and Pearl, Allen, and Penniman (1926) developed a purely synthetic medium which met the requirements admirably. It is primarily a medium for the growth of yeast which is sprinkled over it in powdered form after it has solidified in the culture bottles. The pH is so regulated as to discourage the growth of bacteria and molds which give trouble particularly at low temperatures. This synthetic medium, called S-101, has been used as the standard fly culture medium

ever since in this laboratory. The ordinary stock is cultured in half-pint milk bottles with about one and a half inches of medium in the bottom which is seeded with yeast before the flies are put in the bottle. Five pairs of flies are placed in each bottle which is closed with a cotton plug to permit circulation of air and is kept at a constant temperature of 23°C. The parents are removed a day or two before the offspring begin to emerge from the pupa cases. Bridges and Darby (1933) have since developed a medium with a base of corn-meal and molasses, substances which are however natural food products of variable composition and can in no scientific sense be regarded as forming a constant medium, for which they claim superior qualities. The S-101 medium has in every way proven satisfactory here.

b. Population growth

As has already been noted, Pearl (1925 and 1927) showed that population growth for *Drosophila* follows the typical logistic curve. This means that a population starting at some lower asymptotic level in a favorable environment begins to grow exponentially as Malthus supposed, but as it begins to fill up the available space the crowding factor acts adversely on the death rate or on the birth rate or on both so that the growth rate begins to decline long before the upper limit is reached. Finally, when the space-limited environment can support no larger numbers a state of equilibrium is reached at which the birth rate just balances the death rate. This last phase leads to the upper asymptotic value. The population density from then on remains relatively constant, fluctuating about this upper limit. The population of France, for example, has for some years exhibited this last phase of the cycle.

Evidently it is theoretically possible, and sometimes appears in fact to be the case, that a population may remain relatively stable at the same asymptotic level for a long period of time, and then begin active growth again on a new logistic cycle. What causes this new growth then? Obviously an external environmental change for the better is necessary and this means in effect an enlargement of the environment. In a human population some new means of economic production or distribution may act in this way. The population of Japan, for example, is thought to have remained at a constant level, possibly for centuries, before it began the logistic cycle of growth caused by the industrial revolution when it was brought in contact with Western civilization. Opening up of new territory can have the same effect, which can be felt even though there is little emigration to the new lands. On the other hand, when a group of individuals actually migrates to virgin territory, there is in no true sense any lower asymptotic population level though for purposes of curve fitting one may be assumed and its value taken as the original number of immigrants. This latter situation is probably not uncommon in nature and may be accurately duplicated in the laboratory.

Other approximations to the natural conditions are not so easy to reproduce experimentally. Malthus based his theory of population growth on the assumption that reproduction proceeds by geometric progression while the means of subsistence increase arithmetically. Energy is used up by vital activity and must somehow be replaced or the population will necessarily decline and finally become extinct. In nature, this energy is added at a relatively constant rate from the sun through the green plants. This condition is admirably copied in a balanced aqua-

rium. But as such a symbiotic relationship has not been created in most quantitative population experiments they are not comparable to natural conditions in that respect. As has been mentioned, protozoan populations grow logistically, but, if left in the same culture medium, instead of maintaining an asymptotic level they decline rapidly and finally all encyst or become extinct—the energy flowing in one direction only, the reaction must go to an end. *Tribolium* populations eat their available food supply very slowly, so Chapman found them fluctuating about an asymptotic level for a while but Park showed that eventually they too became extinct if left indefinitely in the same flour. The final decline of such an experimental population does not in itself seriously interfere with comparing the growth period with that of balanced populations, but the lack of an added constant increment of energy undoubtedly has some effect on the growth curve before the upper limit is reached. In this respect, *Drosophila* has a great advantage for population work. Since it is in partial symbiosis with the yeast which is its principal food, the growth of the yeast produces just such an added increment of nourishment (until the food dries out) as is lacking in the case of protozoan and *Tribolium* populations. Of course, many insects naturally live in environmental conditions which are continually running down, requiring them to find a new source of food for continued existence.

L'Heritier and Teissier (1933) set up an environment for *Drosophila* which met all the requirements and beautifully tested this part of the theory. Ten *Drosophila*, 5 males and 5 females, were placed in a large cage. Each day a saucer of food was put in the cage and was removed at the end of twenty days when all the food had dried up. In other words, there was one saucer in the cage the first day, two the second day, three the third day and so on until the twentieth day after which time the number remained constant since the oldest saucer was removed and a new one added each day. The food supply thus never diminished and a constant increment of energy was added to the system each day. Two such experiments were run, and in each a state of equilibrium was reached by about the fortieth day with about 3,200 flies per cage as the asymptotic value. In one series there were 3,200 flies on the 38th day, 3,310 on the 50th day, and 3,290 on the 65th day; in the other series there were 3,010 flies on the 38th day, 3,290 on the 45th and 3,270 on the 51st day. The authors say that judging from the number of pupa cases about 141 imagoes emerged each day, after equilibrium was established, so that the average duration of adult life must have been about 23.3 days. At the last census of the two populations, 34 percent were males and 66 percent females.

c. Duration of life and time of development

The two primary factors producing the growth curve are the rate at which the imagoes emerge from the pupa cases (corresponding to the birth rate of a human population) and the death rate, or, inversely, the length of life. Pearl and Parker (1921) started a long series of investigations on the latter factor, entitled "Experimental studies on the duration of life," by publishing life tables for *Drosophila melanogaster*. More extensive tables were put out three years later (Pearl and Parker, 1924a). Pearl (1922) and Pearl and Doering (1923) compared the life span of *Drosophila* with that of man and of the rotifer *Proales decipiens* by plotting the number of survivors of an original population of 1,000 individuals (loga-

rithmic scale) against the centiles of life span (arithmetic scale) thus putting the life span of all three animals on the same scale. It was found that "at each centile age throughout the life span the number of survivors starting life together, is higher in man than in *Drosophila*." This means, that man more nearly approaches the situation of all the individuals living to the same age then all dying at once than does *Drosophila*. *Proales* approaches this condition considerably more closely so its survivorship—centiles of life span curve—is more nearly rectangular than the others. The curve for the females of one long-wing wild stock was almost indistinguishable from the human curves while vestigial flies had quite a different type of curve which approached a straight line. In both stocks, the females were longer-lived than the males. Brownlee (1924) compared the life span of man with that of *Drosophila* using Pearl's data but employing a different statistical technique and arrived at the same conclusions.

Hyde (1913) working with *Drosophila ampelophila* (= *D. melanogaster*) found two inbred strains, one with an average life span of 37 days and the other with a life span of only 21 days. Crossing the two, he found the F_1 hybrids had a life span of 47 days but the F_2 generation dropped to an average of 29.5 days. An interesting point was that in both original stocks the males had a considerably longer duration of life than the females. Pearl and Parker (1922a) took up the study of the inheritance of the duration of life in *Drosophila* and in the preliminary study concluded:

"A. That there exists in a general population of *Drosophila melanogaster* (or its mutants) genetic differences in respect to duration of life."

"B. That these genetic differences are capable of isolation, by appropriate selection and inbreeding."

"C. That within an even moderately inbred line, the genetic differences in duration of life remain constant over periods of at least 10 to 25 generations or more."

Pearl, Parker, and Gonzalez (1923) crossed a long-lived wild stock with a short-lived vestigial winged mutant stock and found, as Hyde had, that the F_1 offspring had a longer average duration of life than either parent stock. Since the vestigial mutant is a simple recessive characteristic, the F_2 generation aggregated into half long-wing and half-vestigial-wing flies and it was found that the mean duration of life for each type was almost identical to that of the corresponding parent type. Gonzalez (1923) extended this study by working with five different mutant genes of the second chromosome. He found that each of these genes had a definite predictable effect on the duration of life.

In these experiments it was necessary to etherize the flies at the start in order to sex and count them. Pearl and Parker (1922b) therefore tested the effect of etherization on duration of life to see if it was distorting their results. They found that etherizing the flies once, twice, three times or four times at various ages had no appreciable effect on their life span. However, a method of counting the flies without etherization was devised and regularly used in these experiments. A diagram of the tube used for this purpose may be seen on page 275 of Pearl and Parker (1922b) and also on page 30 of *The Biology of Population Growth* (Pearl, 1925). Northrop (1926a) found that an intensity of light of 1,000 meter candles or more shortened the duration of imago life and that in general the rate of aging is proportional to the intensity of light to which the imagoes are exposed. Alpatov and Pearl (1929) studied the influence of temperature. *D. melanogaster* reared (egg

to imago) at 18°C. are larger than those reared at 28°C. and live somewhat longer. The duration of life decreases with rise in temperature over this range and whereas the females always live much longer than the males this difference diminishes with increasing temperature. Loeb and Northrop (1917) also showed that with increased temperature (within the normal range of temperature) the various developmental stages were passed more rapidly and the duration of imago life was shortened. But below 15°C. the life span was again greatly shortened for the stock they used. Studying the nutritional effect, Alpatov (1930) removed larvae from the food before the normal time for pupation and the imagoes which developed from them were small but did not have their life span significantly shortened. On the other hand, normal flies died sooner if given no yeast during adult life. Pearl and Parker (1924b) completely starved flies in the adult stage and the life span was greatly shortened. The survivorship curves for the starved flies were rectangular in form since all the flies tended to die at about the same time. The females still lived longer than the males. Pearl and Parker (1922d) wanted to see if a generalized growth hormone affecting the rate of living might not be found in developing animals. For this purpose they added "embryonic juice" from chicks and from *Drosophila* larvae daily to the food of adult flies, but found no effect upon their duration of life. Northrop (1917b) put sterile eggs on sterile banana and added yeast immediately, or 1, 2, 3, 4, . . . 11, or 12 days later. When the imagoes emerged they were kept on sterile agar-glucose medium (starvation conditions). The later the yeast was added the longer the larval period lasted, and it could be prolonged over 100 percent in this way. When yeast was added immediately, the total span was 19.3 days; when added at the end of 8 days the life span was 25.5 days and when added at the end of 100 days the total life span was 28.9 days. But the imago period remained constant between 10.9 and 11.9 days in any case. This showed, according to Northrop, that "the relative duration of life of each of the three stages is independent of that of the other two stages."

The most interesting of these studies in relation to the present paper was the determination of the effect of adult population density on the duration of adult life by Pearl and Parker (1922c and 1923) and Pearl, Miner, and Parker (1927). In the basic experiment the flies, just a few hours old, were placed in one-ounce glass vials with banana-agar medium seeded with a standard amount of powdered yeast. The vials were closed with cotton plugs permitting circulation of air. Each day the flies were changed to a new vial and any dead flies counted (but not replaced). Two, 4, 6, 8 . . . 125, 150, and 200 flies (twenty steps in all) were initially placed in each vial, there being a total of 530 vials and 13,000 flies in all. As was to be expected, the higher densities considerably shortened the duration of life but the more significant point was that up to a density of between 30 and 55 flies per vial at the start *increasing density significantly prolonged the duration of life.* The statistical work required for this investigation matched the experimental in laboriousness as the crowding factor was calculated separately for each fly as the mean density to which it was exposed throughout its life. Further studies showed that densities above 200 flies per bottle at the start had little further effect in reducing the duration of life. In other experiments, flies were started in high and in low densities and then changed to

the opposite condition after the sixteenth day of life. It was found that crowding has the most marked effect on mortality in early life. Flies which survived densely crowded conditions in early life were nevertheless weakened so that when they were transferred to an uncrowded environment they did not live as long as they would have, had they never been crowded. The general effect of crowding on wild type *D. melanogaster*, then, is to convert "the normal life curve characteristic of the wild-type flies into the diagonal type of curve, with its short absolute duration of life characteristics of vestigial flies at optimal densities of population" (Pearl, 1928, page 147).

The principal work on the duration of life, as just described, was carried on with imagoes but some odd bits of information are available about the growth rate and time required for other stages. Alpatov (1929) did the principal work in this line. He found that in wild type *D. melanogaster*, at 28°C. the majority of eggs hatched in 18 to 24 hours after oviposition. Using a technique of fixation with boiling water he was able to measure samples of larvae at intervals and publish growth curves for them. In general it has been found that the better the feeding the sooner the larvae will pupate and the imagoes emerge. Krafka (1920) found that the imagoes emerge a day earlier when the larvae are fed on Fleischman's yeast than when raised on bananas and that when the food was so dried out that they could just survive, the imagoes emerged about 5 days later than the controls in good food. Northrop (1917a and b) (as has been described) showed that lack of yeast prolonged the larval period. Eigenbrodt (1925) found that flies emerge later from bottles in which the parents were crowded, which might be a food effect. On the other hand, Alpatov (1930) partially starved larvae by removing them from the food medium to plain agar 48 hours after the eggs hatched and found that these larvae pupated earlier than controls kept on food. All workers have found that, within the normal range, the higher the temperature the sooner the larvae develop. Bergner (1928) prolonged the larval period by low temperature and by poor feeding and found the rate of crossing-over was increased by the treatment. Bonnier (1926), using a sex-linked mutant yellow stock, observed his culture bottles every two hours and removed each pupa formed during the preceding period to a separate bottle and later observed these bottles every two hours while the imagoes were emerging. His results were as follows:

	At 25° C.		At 30° C.	
	Males	*Females*	*Males*	*Females*
Hours, egg laying until pupation.....	116.78±.20	116.61±.19	103.37±.43	99.95±.49
Hours, pupation to emergence of imago.....	115.43±.13	111.36±.15	84.16±.34	78.15±.50

High temperature speeded up development in both larval and pupal periods. At 30°C. the females developed significantly faster than the males in both the larval and the pupal stages. At 25°C. the pupal period was significantly shorter for the males than for the females (difference 4.1 hours), but there was no significant difference in the larval period. Stanley (1935) found that wild flies emerge sooner than vestigials while the heterozygous F_1 generation flies are in between but more nearly like the wild type than the vestigials in this respect. Bliss (1926) was interested in finding the best end points to use as indications in measuring the rate of development. He

found that there is a diurnal fluctuation in the rate of emergence of the imagoes, the greatest rate being in the early morning hours and the lowest rate being at night. On the other hand, no such rhythm was found in the rate of pupation, and he concluded that it was impractical to use the emergence of the adults as an indicator of the time of development. I am not altogether convinced of the validity of his findings, and certainly when environmental conditions change the time of imago emergence by as much as several days it can be taken as an indicator of development even if there is a slight diurnal fluctuation.

In the case of the two physiological races of *Drosophila pseudoobscura*, Poulson (1934) reports a very much more marked diurnal fluctuation, almost all of the adults emerging in the early morning hours even when kept at constant temperatures in dark incubators.

Pearl (1928) has summed up these experiments on the rate of growth and the duration of life of *Drosophila* and also of canteloup seedlings raised in the dark without food. "All of the evidence presented in this book [*The Rate of Living*] converges to the conclusion that, in general, the duration of life varies inversely as the rate of energy expenditure during its continuance. *In short, the length of life depends inversely on the rate of living.*"

d. Productivity, fecundity and fertility

There has been considerable confusion in the use of terms describing reproductive activity and it is therefore necessary to briefly state how I shall use them before discussing the problem. The word "fertility" has been used by different authors to mean egg laying, production of sperm, whether or not the eggs hatch, the proportion of eggs which develop into adults, and, finally, the net production of adult offspring. Following the usage of Pearl and Alpatov, I shall use the word *fecundity* when speaking of the number of eggs laid by a female, whether or not the eggs are viable. Males which cannot have offspring and females which lay no eggs will be called *sterile*. The number of adult offspring produced under certain conditions will be called the *net productivity* and the percentage of eggs laid which develop into adults will be called the *percentage emergence* (to avoid confusion with the percentage of eggs which hatch).

Fecundity in *Drosophila* is extremely sensitive to environmental conditions and, as will be shown, genetic factors are quite important. For both these reasons, but more particularly for the former in the case of an inbred stock, there is a great variation in the number of eggs laid by different females and the standard deviation of the number of eggs laid by the same female from day to day is very large. Besides there is some indication that there may be cycles in fecundity while it very definitely changes with age. Couple with this the fact that one female may produce over one hundred eggs in twenty-four hours and it becomes apparent at once that this is a very difficult characteristic to study. As various workers have used widely different stocks and even different species and no two used exactly the same technique, the arithmetic values obtained can only be used for comparison within the particular set of experiments in which they occurred.

Guyénot (1913) counted the number of eggs laid by females when fed on sterile apple with yeast. He found that they laid many more eggs with the latter food conditions, but unfortunately he used very few flies and his results were not very

conclusive. Pearl, Allen and Penniman (1926) found a considerably higher fecundity with their new synthetic medium than with banana agar. Alpatov (1932) showed that underfeeding of the larvae reduced the fecundity of females developing from them. In a set of preliminary experiments, I found that an apparently very minor variation in the yeast fed to adults would make an immediate effect of more than a hundred percent in the fecundity and that the number of eggs laid on any one day was determined to a high degree by the environmental conditions in the few days just preceding. Hyde (1924) says that "egg laying reaction is dependent in no small measure, as is well known, upon the condition of the food." While this must be apparent to anyone doing this work, I do not believe that the degree of sensitivity has been fully appreciated.

Hanson and Ferris (1929) found that mated females lay 50 to 100 percent more eggs than unmated females. This increased egg production was produced to the same degree when the females were mated to sterile males as when they were mated to fertile males. Shapiro (1932) found that mated *Drosophila melanogaster* begin egg laying one or two days after emergence while virgins sometimes do not begin to lay eggs until the seventh day.

Alpatov (1932) developed a new and very convenient method of testing fecundity, a diagram of which may be seen on page 72 of Pearl (1932). The food is put in a watch crystal which is held in place in the mouth of a one-half pint milk bottle by two small pieces of plasticine. The bottle is then turned upside down and kept at a constant temperature. Each day the watch crystal is removed, the number of eggs laid on the food counted and another crystal with fresh food put in the mouth of the bottle. Experience has proven that the flies will lay all their eggs on the food and not elsewhere. Using this technique, he studied the daily egg production curve and the total egg production for *D. melanogaster* females during their entire adult life. He found that flies bred at low temperatures produced more eggs than flies bred at high temperatures, the temperature during adult life being the same in both cases, and that underfeeding as larvae decreased the later egg production as adults. Vestigial-winged flies were found to have a much lower fecundity than normal wild flies. A point of considerable interest was that a negative correlation was found between the duration of adult life and the average egg production per day for the whole producing period, a fact which fits in well with Pearl's rate of living theory.

Hyde (1924) noted: "It is, moreover, a curious fact that the average output of eggs for each female is greatly reduced when she is subjected to mass culture." Pearl, Allen, and Penniman (1926), in testing the effect of this new synthetic medium, placed 1, 2, 4, 8, 16, and 32 pairs of *D. melanogaster* in a series of half-pint stock bottles, removed them at the end of eight days, and counted the offspring. The total reproductivity was the greatest in the bottles with two and with four pairs of parents. The mean net productivity per female per day, however, was greatest with one pair of parents per bottle and dropped steadily with each increase in density. These results might have been due to decreasing viability of the eggs with higher densities, an increasing larval and pupal mortality, reduction in fecundity or all three combined. Of the three, the latter was probably the most important as Pearl's later experiments showed. Pearl and Parker (1922a) did a more extensive experiment of the same kind, studying

the net productivity per day for mated females at different densities of population for the first sixteen days of life. They found that the rate of reproduction varies inversely with density of population according to the formula $\log y = a - bx - c \log x$, where y = the net productivity per mated female per day and x = the mean density of population. Maclagan (1932) fitted Farr's formula to Pearl's *Drosophila* data and to Chapman's data on *Tribolium*. This formula states $\log y = \log a + b \log x$, where y = the number of progeny and x the space per individual. The formula given by Pearl and Parker is an inverted form of the same equation. Pearl (1932) did the major experiments of this series in finding the exact relationship between fecundity and population density, in the course of which a total count of over 100,000 eggs was made. Egg counts were made daily at densities ranging from 2 to 256 flies per bottle, in both half-pint and quarter-pint bottles. The change of rate in egg production was found to be described by the same type of mathematical equation as that which relates mean free path of molecules to density in a gas. It is probable that this was due primarily to the collision rate and general mechanical interference of the flies with each other which presumably increased with increasing density of population. The food area was the same in the half-pint as in the quarter-pint bottles and a comparison of the egg production for the two at various densities shows that density of population is principally a matter of the number of flies per unit area of food rather than the number of flies per unit of air volume. A series of experiments in which the same flies were daily alternated between crowded and uncrowded conditions showed that the crowding factor was immediately expressed in terms of fecundity.

So far as I can find, Duncan (1930) is the only worker who has studied the reproductive capacity of the male of *Drosophila melanogaster*. He found that an 18-day old male would mate with fertile results about once every 20.8 minutes when not disturbed. Experiments were then run in which the male was put with a new virgin female following each copulation and the total number of offspring produced by all these females counted. This treatment slowed down the rate of copulation considerably but the results give a fair idea of the range, at least, of reproductive capacity. Of the ten males tested, the most productive had 14,070 offspring and the least productive had 7,368 offspring (imagoes). The average male was fertile for about 32 days and within limits, it did not matter whether he was first mated when quite young or when quite old. For example, one male was not mated until he was 57 days old and yet remained fertile for 31 days. The fertility (or the rate of net productivity) was highest in the first five days of mating and then dropped steadily, almost in a straight line, up to the end of the fertile period. It would look as though each male has a definite capacity for sperm production which may be used up either quickly or slowly. There was some indication that large males can produce a greater number of offspring than small males. As compared with the male capacity to produce great numbers of spermatozoa, Hyde (1921) reported on three *D. melanogaster* females, A, B, and C, with especially high fecundity records, which produced 2,184, 1,613, and 1,807 eggs respectively for A, B, and C. Female A often produced her own weight in eggs during twenty-four hours and for her whole life span she laid on the average her own weight in eggs every forty-eight hours. In all, she laid 32 times her own

weight in fresh eggs, or comparing the dry weight of the eggs with the dry weight of the fly, she laid 80 times her own weight in eggs.

Moenkhaus (1911) working with *D. ampelophila* found great variations in the number of sterile individuals found in different stocks. Some strains of flies were from 20 to 48 percent sterile while others were 100 percent fertile. He says the inbreeding had little effect upon the proportion of sterile individuals. Wentworth (1913) inbred four pure lines originating from a single pair of orange-eyed mutant flies basing the original selection on size and apparent vigor, and found that the productivity was somewhat different for each and bred quite true to type. His experiment does not show how much of this difference was due to sterile individuals, non-viable eggs, and larval mortality. The net productivity dropped with inbreeding.

Hyde (1913) commenced a large scale series of experiments on the inheritance of fertility, sterility, and fecundity in *Drosophila ampelophela*. Egg laying commences when the females are two or three days old. Hybrid flies had much higher productivity than either parent strain, this being accounted for entirely by a great increase in fecundity with hybridization since the percentage emergence was less than in pure strains. Hyde (1914a) found an inherited defect in the female which prevents oviposition and results in sterility (in the female only). It is carried both by males and females, in which it does not appear phenotypically, so acts like a sex-limited Mendelian recessive although the exact mode of inheritance was not determined. The same worker (Hyde, 1914b), found a very low producing inbred truncate stock which he crossed to a high producing wild stock. Wild females mated to truncate males and truncate females to wild males both had a higher net productivity than females of the corresponding types mated to males of the same type. Brother-sister matings were made up from F_1 hybrids of both reciprocal crosses and they were equally found to be very high producers. The F_2 generations, however, were much smaller producers. A further experiment showed that while the inbred wild stock had about a 75 percent emergence, only one-fifth to one-quarter of the eggs from truncate females mated to truncate males developed into imagoes (20 to 25 percent emergence).

On the other hand, when a truncate female was mated to a wild male, many more of her eggs developed. This accounts for the rise in net productivity with the original cross. The F_1 hybrids crossed brother-sister had a percentage emergence of only 56.6 percent, but a very high egg production, so the net productivity was still higher than the wild type parent stock. Hyde (1914c) further tested the effect of crossing on percentage emergence under two conditions (a) by inbreeding different lines from the same original pairs and later crossing the two lines, (b) by crossing wild stocks from different regions. In the first case, he found that some of the lines from the same progenitor went down in percentage emergence while others did not; on crossing, the offspring were brought up to the level of the higher percentage emergence line. Crossing wild stocks from different sources in some cases brought the percentage emergence just up to the level of the better stock and in other cases produced a better percent emergence than that for either original stock. Twenty different wild stocks taken from various regions were found to have a percentage emergence varying from 80 to 100 percent (Hyde, 1917) while on inbreeding it

dropped to as low as 25 percent. Hyde concluded that inbreeding does not necessarily lower the percentage emergence but its effect depends upon how the genes happen to be selected and combined and likewise the same factor determines whether or not the percentage emergence will be raised by crossing. That is, "inbreeding gives a chance for defects to be brought to the surface" and "low fertility is likely to accompany close inbreeding provided it is not accompanied by rigorous selection." Fecundity, on the other hand, did not decline with inbreeding (Hyde, 1919) and the correlation between the fecundity of the female and the percentage of the eggs which develop into imagoes is very low. Hyde (1924) extended these experiments and this time found that the percentage emergence for wild stocks taken in different localities varies from 67 to 96 percent, most stocks being between 80 and 90 percent. On inbreeding, the percentage emergence of these same stocks dropped to 24 to 84 percent with most of them having a percentage emergence between 45 and 75 percent. Carver (1937) obtained similar results; crosses between wild and vestigial stocks and between wild and hairy stocks gave a higher net productivity than when flies of any one type were mated to flies of the same type.

The inheritance of egg size, a characteristic which is perhaps closely associated with fecundity, has been studied by Warren (1924). Various different stocks were found to have characteristic and constant ranges for egg length. When two stocks with different egg lengths were crossed, the F_1 heterozygous females almost invariably laid eggs intermediate in size between those for the two parent stocks. The largest eggs were found in an abrupt stock (average length .522 mm. based on the measurement of 1,000 eggs) while a bar-eyed stock had the shortest average egg length found (.445 mm.). The length of the eggs produced by a single female varied slightly from day to day but egg length did not vary with either the size or the age of the females and was not affected by temperature.

e. Effect of the environment on the individual and on the genetic ratio

There is no older or more bitter argument in the realm of science than that relating to the relative importance of heredity and environment. It still rages with unabated violence in popular discussions but biologists, tiring of the fight, called a truce some years back after the retreat of the Lamarckians and were willing to let it go with saying that both are important. Obviously, in an inbred, genetically constant stock all the differences between individuals are to be accounted for by environmental influences while in a constant environment with a mixed stock all the differences between individuals are to be attributed to varied inheritance (unless someone can think of a third factor outside the realm of cause and effect). So, to eliminate undesired variables, the geneticists have based all their conclusions on animals raised under nearly optimal environmental conditions while physiologists like to work with animals of inbred, genetically constant stocks.

Recently, however, to an increasing extent workers have begun to attack this problem, which is of fundamental biological importance, by quantitative methods which are yielding tangible results. *Drosophila* is an ideal animal for this since so much is known of its genetic constitution and at the same time it is so sensitive to environmental influences. The papers just reviewed show how profoundly such physiological characteristics

as fecundity, fertility, longevity, and speed of development are influenced by both factors. An experiment by Dobzhansky (1935) strikingly illustrates the problem and the need for further work along the same lines. There are two races, A and B, of *D. pseudoobscura* alike morphologically, but not interfertile with each other. Race B is said to be found most frequently in cool, moist, equable climates, while race A inhabits areas with warmer and more variable climatic conditions. Dobzhansky found that females of race A produce more eggs than those of race B at 25° and 27.5°C. while females of race B produce more eggs than those of race A at 9°, 14°, and 19°C. It seems probable that there is some temperature between 19° and 25° at which females of races A and B lay the same number of eggs. At this temperature no genetical difference would appear. Clearly, a single, constant environment would not suffice for a genetic study in a case like this. It is necessary to have a quantitative comparison of the effect of both variables (hereditary and environmental) in order to understand the distribution and competition of the two races in nature. Another illustration, of a rather different sort, might be cited from a paper by Morgan (1912). A simple Mendelian sex-linked dominant mutation called "abnormal abdomen" turned up in a wild stock of *Drosophila* and behaved perfectly normally in inheritance when the food conditions were good. But in old cultures, or when the larvae developed in dried-out food, flies with this mutant gene showed no evidence of it phenotypically. That these flies actually carried the gene was demonstrated by the fact that their offspring developed the abnormality if raised in good culture conditions. Braun (1938) has just described the effect of environmental conditions upon the manifestation of a new recessive, autosomal gene, a-III (according to Schaeffer in chromosome III, near sepia) which produces an abnormal phenotype very similar to Morgan's "abnormal abdomen." In this case, however, dry food, old food, too little food, and overcrowded stocks favor the phenotypical expression of this gene.

Neel (1937) reports a sex-limited mutation, evaginated, in the male only of *Drosophila funebris* which is influenced by environmental conditions in much the same way. In good cultures it may appear in only 5 to 10 percent of the males carrying it genetically while it appears phenotypically with a much greater frequency in poor culture conditions and at high temperatures.

A considerable amount of work has been done by Driver (1931), Baron (1935), Luce (1935) and others on the facet number of the bar-eyed mutant of *Drosophila melanogaster* as affected by temperature. The facet number varies inversely with temperature during development but more particularly so above 21° which seems to be a critical point. There is only a certain period of development at which the temperature has this effect, however. The lower the temperature the longer is the larval period so the longer the "temperature effective" period lasts in days; it is also relatively somewhat longer at low temperatures. This "temperature effective period" falls within the third larval instar according to Driver. An eyeless or nearly eyeless condition occurs in some bar mutants and in these stocks the proportion of such individuals increases with rising temperature. Baron thinks this may be due partly to a selective death rate.

Alpatov and Pearl (1929) noted that flies developing at 18°C. are larger than those developing at 28°C. and Alpatov (1932) showed that both the length and

width measurements of the wings of wild-type flies were smaller if the larvae were underfed or raised at a high temperature. Imai (1933) found that, whereas the wing measurements are always greater in the female than in the male, this difference is most marked at higher temperatures. He also found that length of the femur of all three legs decreases with rise in temperature but that there is comparatively little difference between the sexes and this difference does not increase with rising temperature. Harnly (1930) discovered that in vestigial *Drosophila melanogaster* males a rise in temperature from 18.3°C. to 29.0°C. produced a very slight *lengthening* of the wings; between 29°C. and 30°C. the wings increase 25 per cent in length, and from 30°C. to 31°C. they increase 70 percent in length. His figures for male and female wing lengths of vestigial flies are given below:

TEMPERATURE DURING DEVELOPMENT	WING LENGTH, MALES	WING LENGTH, FEMALES
18.3°C.	.64 ± .0026 mm.	.61 ± .0024 mm.
29.0°C.	.74 ± .0030 mm.	.74 ± .0023 mm.
30.0°C.	1.00 ± .0099 mm.	.79 ± .0037 mm.
31.0°C.	1.70 ± .0114 mm.	1.12 ± .0209 mm.

It may be noted from the above table that the wings of the males begin to be greatly affected by temperature starting at 29°C. while the wings of females are not greatly affected until a temperature of 30°C. is reached. The opposite behavior of wild and vestigial flies in respect to wing length with rising temperature may indicate an effect of this gene more profound than its determination of the type of wing. Hersh and Ward (1932) found that heterozygous wild-vestigial flies behave more like wild flies than like vestigial flies in respect to the effect of temperature on wing size. Those with long-wing mothers and vestigial-wing fathers have larger wings, on the average, at all temperatures than those of the reciprocal cross. Harnly and Harnly (1935) found a recessive sex-linked gene modifier (dimorphous), for the gene vestigial which affects wing and eye size. At 25°C. it shows in the male only, but above this temperature it shows in both sexes. In the temperature range from 16°C. to 32°C. all variations in wing type are found in the male ranging from vestigial wings (at low temperatures) to normal long-wings at high temperatures. The wings of vestigial males with this gene are larger than those of females with the gene at all temperatures up to 32°C. at which point the wings of the two sexes are the same size.

Eigenbrodt (1930) found that in a homologous bar-eyed stock of *Drosophila melanogaster* the body weight, thorax length, and head width all vary inversely with temperature, these relationships plotting very nearly as straight lines between 17°C. and 29.5°C. He, too, found that wing length and width vary inversely with temperature, but more markedly so in the lower temperature range. Temperature not only changes the size of the flies but their bodily proportions also, since the correlation coefficient of wing length-thorax length varies directly with temperature.

Plunkett (1926) found that the number of bristles varied inversely with temperature in a range from 14°C. to 30°C. in his stock of *Drosophila melanogaster*. At any temperature, the more flies which emerged per bottle, the fewer were the average number of bristles per fly. Eigenbrodt (1925) obtained what he considered to be crowded larval conditions by leaving 5 pairs of parents in 8-dram culture vials for six days at 27°C. (or 9 days at 17°C.). Those emerging from these vials had fewer hairs, fewer teeth in the sex comb

and greater uniformity in size than flies from uncrowded vials and they took longer to develop.

The factors just discussed all have a direct effect upon the phenotypical expression of certain genes. On the other hand, a selective death rate in the larval and pupal periods may upset the expected genetic ratios of the imagoes which do emerge without altering the character of the individuals which survive.

Mann (1923) treated an inbred stock of *Drosophila melanogaster* with a great variety of semi-poisonous substances (arsenic, quinine, lead acetate, methylene blue, lithium carbonate, etc.) in the hope of obtaining mutations, but only got one mutation to 15,000 flies as compared with one mutation to 23,000 flies in the normally fed controls. A probable explanation would seem to be that as most mutants are weaker than the wild type, those which occurred in the poisoned food ran a greater risk of being killed in the larval stage and so a smaller percentage were seen as adults.

Morgan and Tice (1934) said that crowding caused less than the expected number of rudimentary wing and strap-wing flies to appear in crosses. Remarking on the divergence of expected from observed ratios in genetical work with *Drosophila*, Bridges (1921) says that ". . . overcrowding was the largest source of disturbance in most of the early work as well as in some of the later." Under the most optimal food conditions they could devise, Harnly and Harnly (1929) could obtain only 0.9 vestigials to 1.0 long-wing flies in a back-cross of vestigials to heterozygous flies (the expected ratio was 1.0 to 1.0 since the gene vestigial is a simple recessive). Better culture conditions gave a greater total productivity of both types. When small vials were used the divergence was much greater, while reducing the time the parents were left in the bottles gave nearer to the expected ratios, so the authors concluded that a selective larval rate which increased with crowding was the cause. Clausen (1924) backcrossed black cinnabar vestigial males to heterozygous females in half-pint bottles with single pair matings and obtained the expected 1 to 1 ratio of offspring. He says that he made such matings in six small vials with three pairs of parents to each vial and obtained less than the expected number of offspring of the recessive type. This he thought was due to larval crowding and consequent selective mortality.

3. OTHER INSECTS, ETC.

While *Tribolium* and *Drosophila* are the only two insects whose population physiology has been thoroughly studied, there has been some experimental work done on other insect and crustacean populations. Norris (1936) has studied longevity and fecundity in another flour beetle, *Trogoderma versicolor*. As adults the males live about eleven days and the females live about twenty days and lay somewhat over a hundred eggs in all. When these adult beetles are put in empty dishes and given neither food nor water, they live just as long and lay just as many eggs as when food and water are available. The feeding during the larval stage, however, makes a considerable difference in the fecundity. The total number of eggs laid by females was as follows: whole wheat flour, 104 eggs; oatmeal, 105 eggs; maize flour, 83 eggs; and wheat flour, 67 eggs. Norris (1933) has also studied the Phycitid moth, *Ephistia kühniella*, which lives in flour during the larval period. Its reactions are very similar to those of the beetle, *Trogoderma*, and it is cultured in exactly the same way. No food or water

is required by the adults, while poor food or an abnormally small amount of food during the larval period reduces fecundity. Virgin females produce no eggs. The fault for unsuccessful mating lies with the male, according to Norris. When reared at 27°C. from 10 to 59 percent of the matings are completely unsuccessful (and no eggs are laid) and when reared at 30°C., 96 to 100 percent are unsuccessful, but high temperature (30°C.) does not disturb mating if the moths are exposed to it during the adult period only. Moths reared in crowded bottles have more unsuccessful matings than those reared in uncrowded conditions.

Maclagan (1932) reviewed Pearl's work on *Drosophila* and Chapman's work on *Tribolium* and became particularly interested in the effect of population density on fecundity. His question was whether crowding (that is, number of animals per unit volume) has a direct effect in itself or whether it is simply an effect of available food supply. The grain weevil, *Calandra granaris*, can be cultured in a bottle of whole wheat grains and, calculating the population density in terms of grains per animal, Maclagan found an optimal density for reproduction (that is crowding up to a certain point gave a higher rate of reproduction than no crowding). He then mixed wheat grains with an equal number of small glass beads of about the same size and in this way doubled the volume without increasing the food supply. Weevils placed in this mixture at a certain population density had exactly the same reproductive rate as those placed in wheat grains alone at twice the density per unit volume. Thus the reproductive rate was controlled by the number of grains of food which was the same in both cases and was unaffected by the space relationship.

Larson and Fisher (1924) worked with the cowpea weevil, *Brachus quadrimaculatus* Fab. This insect may live for a considerable period and lay many eggs without having either food or water. He found that access to water alone increased the life span by about 10 days while a diet of sugar-water greatly increased the longevity. An interesting fact was that feeding *reduced* the fecundity of females for the first few days, though they laid more eggs all told than starved females since they lived so much longer. This is what might be expected from Pearl's rate of living theory. Virgin females produce only a few eggs, none of which are viable.

Glaser (1923) raised house flies (*Musca domestica*) and biting stable flies (*Stomoxys calcitrans*) in horse manure and kept the adults in bottles with a food solution (horse blood serum or bouillon or egg white, etc.) placed on a gauze stopper in the mouth of the bottle. The type of adult feeding was found to have a great influence on both longevity and fecundity (the better the food the higher the fecundity and the greater the longevity). Mated females of both species laid more eggs than unmated females. Cattle horn flies (*Lyperosia irritans*) were reared successfully in cow dung from eggs laid by gravid females removed from cattle, but the flies thus reared would lay no eggs.

Miastor metralans is a dipteran which ordinarily reproduces paedogenetically in autumn, winter, and spring but in early summer pupae occur which give rise to male and female imagoes. Harris (1923) reared these animals in the laboratory on a malt agar medium in Petri dishes and found that pupa-larvae occur in old and crowded cultures. He therefore concluded that crowding, or more likely the accumulation of waste products as the result of crowding, is the ordinary stimu-

lation agent for the production of the sexual forms.

Holdaway and Smith (1932) worked with *Alysia manducator*, a small insect which lays its eggs in the larvae of the blow-fly, only one egg per larva as a rule. They plotted the sex ratio of the emerging parasites against the size of the host puparia, and found a high correlation between small puparia and a high proportion of males.

Trichogramma evanescens is a small chalcid fly (order Hymenoptera) which lays its eggs inside the eggs of other insects (usually moths). The female will avoid laying more than one of her eggs in the egg of a host. However, under crowded conditions or when few host eggs are available, two, three, or four *Trichogramma* eggs may be placed in one host egg. When three or more eggs are laid in one host egg, Salt (1936) calls them "superparasitized." In such cases the larvae have to compete for food and usually only one emerges as an adult. The "visitors" are small, weak, and sometimes deformed and the greater the amount of superparasitism the greater is the percentage of male emergents. Thus crowding of the adult parasite population increases the amount of superparasitism and results in greater proportion of males in the following generation.

The population physiology of *Moina* and *Daphnia*, two genera of the order Cladocera, sub-class Branchiopoda, has been studied by several workers. These are little water fleas found all over the world in lakes, ponds, and small temporary bodies of fresh water. Under good conditions they reproduce by diploid parthenogenesis, no sexual eggs and no males being formed; sexually produced winter eggs carry the species over winter, droughts and other unfavorable periods. Banta and Brown (1929a) showed with *Moina macrocopa* that crowding the mothers caused them to produce male offspring. A single female alone in a bottle rarely ever produces a male offspring while ten females in 75 cc. of medium produce about 42 percent male offspring. The amount of food present made little difference and the authors thought that excretory products in the culture medium were responsible for the production of males. Other species of Cladocera and other aquatic animals placed with the *Moina* females acted in this respect just as effectively in crowding as having a greater number of *Moina* themselves.

Whatever is the factor in the waste-products which is responsible for the production of males, it is apparently non-volatile but easily broken down by evaporation or allowing the medium to stand idle for some time (Banta and Brown, 1929b). Banta and Brown (1929c) report that the development of the mothers is retarded by crowding and by accumulated excretory products and that this is closely associated with the production of male offspring.

Light doses of ethyl alcohol, filtrates of dried adrenal cortex, thyroid, thymus, and muscle tissue all accelerated the rate of development of *M. macrocopa* mothers (Banta and Brown, 1929d). If they are crowded, the addition of any one of these substances to the medium tends to counteract the ordinary effects of crowding, so less males are formed. This would seem to indicate that the food concentration is more important than the presence or absence of excretory products. A retardation in the rate of development of the mothers was accomplished by Banta and Brown (1930) by treating them with either choloretone, phenyl urethone, or potassium cyanide and mothers so retarded produced more than the normal percentage of males in their first broods of young.

The temperature effect on male production of moderately and densely crowded mothers is rather puzzling (Brown and Banta, 1932). From 14° to 21°C. and above 30°C. the greater the crowding of the mothers the greater the percentage of male offspring. But below 14°C. and between 21°C. and 30°C. the greatest production of males occurs where the mothers are only moderately crowded. In other words, between 21°C. and 30°C. and below 14°C. there is an optimal density (neither the highest nor the lowest degree of crowding) for male production while at other temperatures no such optimal point appears. Brown and Banta (1935) placed two young *Moina* mothers in 75, 50, 30, 20, 10, 7.5, and 2.5 millimeters of culture medium and cultures of each volume were made up with 1/15, 1/25, 1/50, and 1/100 concentration of a standard bacterial suspension (the bacteria serves as food for the *Moina*). The average total production of young per female varied inversely with the food concentration; the volume being constant, while the food concentration had little effect on the sex ratio. But the volume had a great deal to do with the sex ratio (14.2 percent males produced in 75 ml. and 60.6 percent males produced in 2.5 ml. of medium) and the volume also had a great effect upon the total number of offspring per female. Banta (1937) has summed up this experimental work and says that observations of these animals in natural ponds confirm the idea that crowding is the normal stimulating factor for male production.

Ingle, Wood, and Banta (1937) raised *Daphnia longispina* on a manure infusion culture medium. Diluting the medium by adding 36 parts of water to one part of normal medium produced starvation effects. Animals starved throughout life lived about 40 percent longer than well-fed animals while animals starved for 11, 14 or 17 instars and then well fed lived still longer. The starved animals are smaller but if normal feeding is given even after the 18th instar they begin to grow rapidly and approach the maximum body length of well-fed animals. Starvation also reduces the number of offspring, but if the animals are first starved, then fed, they begin to reproduce faster than the normal rate and the total production is nearly as great as if they had been well-fed throughout life. Starvation decreases the rate of the heart beat, indicating a slower rate of metabolism. This is all exactly as might have been predicted by the rate of living theory.

MacArthur and Baillie (1929) found that duration of life varied inversely with temperature in *Daphnia magna*. Crowding, lowered temperature and other unfavorable conditions increase male production as in *Moina*.

Fowler (1931) found that groups of *Daphnia* give a mass protection to the individual from such toxic reagents as $CaCl_2$, KOH, NaOH, KCl, etc. *Daphnia* living in dilute solutions of KOH and NaOH significantly weakened the concentration of these bases.

SUMMARY

In summarizing this long review of the literature it should be especially remembered that this work was done primarily with animal aggregations held together by lack of space or by attraction to the same environment rather than by social instinct. Those beneficial effects which have been found to result from limited crowding are the direct results of the members present and are not due to any division of labor. Allee and others have pointed out that such elementary benefits probably were a large factor in the original development of the social instinct which

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led in time to the evolution of highly integrated societies with specialization and division of labor among the individuals. In organized societies the direct results of crowding may be obscured to some degree and are certainly harder to evaluate, but there is reason to believe that the same fundamental principles still operate. The danger of accumulated waste products is just as real in a crowded human community as in an over-populated drop of hay infusion, though in the former organized activity may eliminate the evil consequences so long as there is no disruption in the smooth functioning of the society.

On the credit side of the ledger, it has been shown that in such diverse forms as protozoa, crustaceans, worms, marine and fresh water fish, and amphibians the formation of groups may be a protection against toxic substances dissolved in the liquid medium, the presence of noxious solids, extremes of temperature, and other elements of bad environment. Under certain conditions a group of these animals may bring the medium more nearly to optimal conditions or perhaps contribute some important substance to it and so increase their own rate of growth or reproduction. Increasing population density up to a certain point has been shown to increase the longevity of *Drosophila* and to increase the net rate of reproduction of *Tribolium*.

On the other hand, severe crowding is almost invariably harmful. The accumulation of metabolic waste products in a liquid medium decreases the longevity, growth, and reproductive rate of animals living in it. A decreased food supply, one of the results of crowding, usually, though not invariably, reduces the rate of reproduction and decreases the size and vitality of the animals. The mechanical disturbance of the individuals in crowded conditions reduces the rate of growth in tadpoles and is a major factor in reducing the fecundity and longevity of *Drosophila*, while the practice of egg eating as well as the bad effects of conditioned flour reduces the net rate of reproduction in crowded *Tribolium* populations.

The population physiology has been worked out in great detail for adult *Drosophila melanogaster* and one or two nearly related species and inherited differences have been studied. Pearl has determined the population growth curve for *Drosophila* and its mutants and has shown how two of its major variables, fecundity and duration of adult life, are directly influenced by crowding as the population grows. L'Heritier and Teissier (1933) have demonstrated a *Drosophila* population in dynamic equilibrium with its environment. Hyde, Pearl and his students, and others have shown in a number of cases how fecundity and fertility may be inherited and the part played by inbreeding, cross-breeding, and selection. Besides all this, a great deal of information is now available on the influence of other environmental factors, particularly temperature, on the speed of development, mortality, fecundity, and morphological characteristics of individuals.

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LIST OF LITERATURE

ADOLPH, E. F. 1931. The size of the body and the size of the environment in the growth of tadpoles. *Biol. Bull.*, Vol. 61, pp. 350–375.

ALLEE, W. C. 1925. The effect of bunching on oxygen consumption in land isopods. *Anat. Rec.*, Vol. 31, p. 336.

——. 1926. Studies in animal aggregations, causes and effects of bunching in land isopods. *Jour. Exp. Zool.*, Vol. 45, pp. 255–277.

——. 1927. Studies in animal aggregations: some physiological effects of aggregation upon the brittle starfish, *Ophioderma brevispina*. *Jour. Exp. Zool.*, Vol. 48, pp. 475–495.

——. 1928. Studies in animal aggregations: mass

protection from fresh water for *Procerodes*, a marine turbellarian. *Jour. Exp. Zool.*, Vol. 50, pp. 295–318.

——. 1931. Animal Aggregations. *Chicago* (Univ. of Chicago Press).

——. 1933. Studies in animal aggregations: further analyses of the protective value of biologically conditioned fresh water for the marine turbellarian, *Procerodes*. *Physiol. Zool.*, Vol. 6, pp. 1–22.

——. 1934. Recent studies in mass physiology. *Biol. Rev.*, Vol. 9. pp. 1–48.

——, and E. S. Bowen. 1932. Studies in animal aggregations: mass protection against colloidal silver among goldfishes. *Jour. Exp. Zool.*, Vol. 61, pp. 185–207.

——, E. S. Bowen, J. C. Welty, and R. Oesting. 1934. The effect of homotypic conditioning of water on the growth of fishes, and chemical studies of the factors involved. *Jour. Exp. Zool.*, Vol. 68, pp. 183–213.

——, and J. R. Fowler. 1932. Studies in animal aggregations: further studies on oxygen consumption and autotomy of the brittle star, *Ophioderma*. *Jour. Exp. Zool.*, Vol. 64, pp. 33–50.

——, R. B. Oesting, and W. H. Hoskins. 1936. Is food the effective growth promoting factor in homotypically conditioned water? *Physiol. Zool.*, Vol. 9, pp. 409–432.

Alpatov, W. W. 1929. Growth and variation of the larvae of *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol. 52, pp. 407–432.

——. 1930a. Phenotypical variation in body and cell size in *Drosophila melanogaster*. *Biol. Bull.*, Vol. 58, pp. 85–103.

——. 1930b. Experimental studies on the duration of life. XIII. The influence of different feeding during larval and imaginal stages on the duration of life of the imago *Drosophila melanogaster*. *Amer. Nat.*, Vol. 64, pp. 37–55.

——. 1932. Egg production in *Drosophila melanogaster* and some factors which influence it. *Jour. Exp. Zool.*, Vol. 63, pp. 85–111.

——, and R. Pearl. 1929. Experimental studies on the duration of life. XII. Influence of temperature during the larval period and adult life on duration of life of the imago of *Drosophila melanogaster*. *Amer. Nat.*, Vol. 63, pp. 38–67.

Alverdes, F. 1927. Social Life in the Animal World. *New York* (Harcourt, Brace and Co.). Pp. 216.

Banta, A. M. 1937. Population density as related to sex and to evolution in Cladocera. *Amer. Nat.*, Vol. 71, pp. 34–49.

Banta, A. M., and L. A. Brown. 1919a. Control of sex in Cladocera. I. Crowding the mothers as a means of controlling male production. *Physiol. Zool.*, Vol. 2, pp. 80–92.

——, ——. 1919b. Control of sex in Cladocera. II. The unstable nature of the excretory products involved in male production. *Physiol. Zool.*, Vol. 2, pp. 93–98.

——, ——. 1919c. Control of sex in Cladocera. IV. Relation between the rate of the mother's development and the sex of her young. *Physiol. Zool.*, Vol. 2, pp. 302–308.

——, ——. 1919d. Control of sex in Cladocera. V. Experimentally accelerated development of mothers and sex of young; mammalian endocrine substances without specific effect on cladocerans. *Physiol. Zool.*, Vol. 2, pp. 309–321.

——, ——. 1930. Control of sex in Cladocera. VI. By treatment with drugs. *Physiol. Zool.*, Vol. 3, pp. 48–55.

Barker, H. A., and C. V. Taylor. 1931. A study of the conditions of encystment of *Colpoda cucullus*. *Physiol. Zool.*, Vol. 4, pp. 620–634.

Baron, A. L. 1935. Facet number in *Drosophila melanogaster* as influenced by certain genetic and environmental factors. *Jour. Exp. Zool.*, Vol. 70, pp. 461–489.

Baumberger, J. P. 1919. A nutritional study of insects with special reference to microörganisms and their substratum. *Jour. Exp. Zool.*, Vol. 28, pp. 1–81.

Beers, C. D. 1928. Rhythms in infusoria, with special reference to *Didinium nasutum*. *Jour. Exp. Zool.*, Vol. 51, pp. 485–493.

Bergner, Dorothy A. 1928. The effect of prolongation of each stage of the life-cycle on crossing over in the second and third chromosomes of *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol. 50, pp. 107–163.

Bliss, C. I. 1926. Temperature characteristics for pre-pupal development in *Drosophila melanogaster*. *Jour. Gen. Physiol.*, Vol. 9, pp. 467–495.

Bodenheimer, F. S. 1936. Population problems of social insects. *Biol. Rev.*, Vol. 11, pp. 393–430.

Bohn, G. and Anna Drzewina. 1920. Variations de la sensibilité à l'eau douce des *Convoluta*, suivant les états physiologiques et le nombre des animaux en expérience. *Compt. rend. de l'Acad. des Sci.*, T. 171, pp. 1023–1025.

——, ——. 1923. Action toxique du rouge neutre en présence de la lumière. *Compt. rend. Soc. de Biol.*, T. 89, pp. 386–388.

——, ——. 1928. Nouvelles recherches sur les effets de masse dans les agglomérations animales et essais d'interprétation. *Compt. rend. Soc. de Biol.*, T. 99, pp. 1567–1570.

——, ——. 1932. Accélération et inhibition de la croissance des plantes par l'argent métallique. *Compt. rend. Soc. de Biol.*, T. 109, pp. 638–641.

Bohn-Drzewina, Anna and G. 1926. Influence de la température sur le sperme d'Oursin, en fonc-

tion de la masse. *Compt. rend. Soc. de Biol.*, T. 95, pp. 376–378.

BONNIER, G. 1926. Temperature and the time of development of the two sexes in *Drosophila*. *Brit. Jour. Exp. Biol.*, Vol. 4, pp. 186–195.

BRAUN, WERNER. 1938. Opposite effect of environmental factors on similar phenotypes. *Amer. Nat.*, Vol. 72, pp. 180–192.

BRIDGES, C. B. 1921. Gametic and observed ratios in *Drosophila*. *Amer. Nat.*, Vol. 55, pp. 51–61.

——, and H. H. DARBY. 1933. Culture media for *Drosophila* and pH of media. *Amer. Nat.*, Vol. 67, pp. 437–472.

BROWN, L. A., and A. M. BANTA. 1932. Sex control in Cladocera. VII. Male production in relation to temperature. *Physiol. Zool.*, Vol. 5, pp. 218–229.

——, ——. 1935. Control of sex in Cladocera. VIII. Food and crowding as factors in male production. *Physiol. Zool.*, Vol. 8, pp. 138–155.

BROWNLEE, J. 1924. The similarity of age vitality in invertebrates and man based on Professor Raymond Pearl's data. *Amer. Nat.*, Vol. 58, pp. 558–564.

CARPENTER, KATHLEEN E. 1930. Further researches on the action of metallic salts on fishes. *Jour. Exp. Zool.*, Vol. 56, pp. 407–422.

CARVER, GAIL L. 1937. Studies on productivity and fertility of *Drosophila* mutants. *Biol. Bull.*, Vol. 73, pp. 214–220.

CHAPMAN, R. N. 1924. Nutritional studies on the confused flour beetle, *Tribolium confusum* Duval. *Jour. Gen. Physiol.*, Vol. 6, pp. 565–585.

——. 1926. Inhibiting the process of metamorphosis in the confused flour beetle. *Jour. Exp. Zool.*, Vol. 45, pp. 293–299.

——. 1928. The quantitative analysis of environmental factors. *Ecology*, Vol. 9, pp. 111–122.

——. 1933. Experimental demonstration of internal resistance and population cycles. *Anat. Rec.*, Vol. 57, Supplement No. 4 (abstract) p. 102.

——, and LILLIAN BAIRD. 1934. The biotic constants of *Tribolium confusum* Duval. *Jour. Exp. Zool.*, Vol. 68, pp. 293–305.

——, and W. Y. WHANG. 1934. An experimental analysis of the cause of population fluctuations. *Science*, Vol. 80, pp. 297–298.

CHURCH, FRANCES. 1927. The effect of crowding on the rate of growth in fishes. *Thesis*, University of Chicago Library.

CLAUSEN, R. E. 1924. The inheritance of cinnabar eye-color in *Drosophila melanogaster*, including data on the locus of Jaunty. *Jour. Exp. Zool.*, Vol. 38, pp. 423–436.

CREW, F. A. E. 1937. The sex ratio. *Amer. Nat.*, Vol. 71, pp. 529–557.

CUTLER, D. W., and L. M. CRUMP. 1923a. The rate of reproduction in artificial culture of *Colpidium colpoda*. Part I. *Biochem. Jour.*, Vol. 17, pp. 174–186.

——, ——. 1923b. The rate of reproduction in artificial cultures of *Colpidium colpoda*. Part II. *Biochem. Jour.*, Vol. 17, pp. 878–886.

——, ——. 1924. The rate of reproduction in artificial culture of *Colpidium colpoda*. Part III. *Biochem. Jour.*, Vol. 18, pp. 903–912.

DARBY, H. H. 1930. Studies on growth acceleration in protozoa and yeast. *Jour. Exp. Biol.*, Vol. 7, pp. 308–315.

DAVEY, W. P. 1917. The effect of X-rays on length of life of *Tribolium confusum*. *Jour. Exp. Zool.*, Vol. 22, pp. 573–592.

——. 1919. Prolongation of the life of *Tribolium confusum* apparently due to small doses of X-rays. *Jour. Exp. Zool.*, Vol. 28, pp. 447–458.

DOBZHANSKY, TH. 1935. Fecundity in *Drosophila pseudoobscura* at different temperatures. *Jour. Exp. Zool.*, Vol. 71, pp. 449–464.

DRIVER, E. C. 1931. Temperature and gene expression in *Drosophila*. *Jour. Exp. Zool.*, Vol. 59, pp. 1–28.

DRZEWINA, ANNA, and G. BOHN. 1920. Action de l'argent colloïdal sur les éléments reproducteurs et les premiers stades du développement chez l'Oursin. *Compt. rend. Soc. de Biol.*, T. 83, pp. 1600–1602.

——, ——. 1921a. Variations de la susceptibilité aux agents nocifs avec le nombre des animaux traités. *Compt. rend. de l'Acad. des Sci.*, T. 172, pp. 485–487.

——, ——. 1921b. La défense des animaux groupés vis-à-vis des agents nocifs. *Compt. rend. de l'Acad. des Sci.*, T. 172, pp. 779–781.

——, ——. 1921c. Action nocive de l'eau sur les Stentors, en fonction de la masse du liquide. *Compt. rend. Soc. de Biol.*, T. 84, pp. 917–920.

——, ——. 1921d. Variations dans le temps de la résistance aux agents physiques et chimiques, chez *Rana fusca*. *Compt. rend. Soc. de Biol.*, T. 84, pp. 963–965.

——, ——. 1921e. Sur des phénomènes d'autoprotection et d'autodestruction chez des animaux aquatiques. *Compt. rend. de l'Acad. des Sci.*, T. 173, pp. 107–109.

——, ——. 1922. Sur des phénomènes d'autodestruction et d'auto-agglutination chez les *Convoluta*. *Compt. rend. de l'Acad. de Sci.*, T. 174, pp. 330–332.

——, ——. 1923. Variations dans le temps du pouvoir fécondant du sperme d'Oursin traité par des substances nocives, en rapport avec son degré de dilution. *Compt. rend. Soc. de Biol.*, T. 89, pp. 383–386.

——, ——. 1926a. Aciton de l'argent métallique sur le sperme et les larves d'Oursin. *Compt. rend. de l'Acad. des Sci.*, T. 182, pp. 1651–1652.

——, ——. 1926b. Action antagoniste de l'argent et d'étain métallique sur les êtres vivants. *Compt. rend. de l'Acad. des Sci.*, T. 183, pp. 571–572.

——, ——. 1926c. Influence d'acide carbonique sur le sperm d'Oursin, en fonction de la masse. *Compt. rend. de l'Acad. des Sci.*, T. 183, pp. 317–318.

——, ——. 1926d. Activation par la lumière des effets de l'argent sur *Convoluta*. *Compt. rend. de l'Acad. des Sci.*, T. 183, pp. 677–679.

——, ——. 1927a. Influence des parois des vases sur les réactions des animaux. *Compt. rend. de l'Acad. des Sci.*, T. 185, pp. 875–877.

——, ——. 1927b. Effets tardifs de l'argent métallique sur les ceufs d'Oursin. *Compt. rend. Soc. de Biol.*, T. 97, pp. 1522–1524.

Duncan, F. N. 1930. Some observations on the biology of the male *Drosophila melanogaster*. *Amer. Nat.*, Vol. 64, pp. 545–551.

Eddy, M. W. 1926. The effect of aggregation upon the rate of respiration in *Amiurus* and *Schilbrodes*. *Anat. Rec.*, Vol. 34, pp. 110–111.

Eigenbrodt, H. J. 1925. The somatic effects of certain environmental conditions on a homozygous race of *Drosophila*. *Thesis*, University of Illinois Library.

——. 1930. The somatic effects of temperature on a homozygous race of *Drosophila*. *Physiol. Zool.*, Vol. 3, pp. 392–411.

Erdmann, R., and L. L. Woodruff. 1916. The periodic reorganization process in *Paramecium caudatum*. *Jour. Exp. Zool.*, Vol. 20, pp. 59–97.

Evans, Gertrude. 1936. The relation between vitamins and the growth and survival of goldfishes in homotypically conditioned water. *Jour. Exp. Zool.*, Vol. 74, pp. 449–476.

Ford, John. 1937. Research on populations of *Tribolium confusum* and its bearing on ecological theory: a summary. *Jour. Animal Ecol.*, Vol. 6, pp. 1–14.

Fowler, J. R. 1931. The relation of numbers of animals to survival in toxic concentrations of electrolytes. *Physiol. Zool.*, Vol. 4, pp. 214–245.

Gause, G. F. 1931. The influence of ecological factors on the size of population. *Amer. Nat.*, Vol. 65, pp. 70–76.

Glaser, R. W. 1923. The effect of food on longevity and reproduction in flies. *Jour. Exp. Zool.*, Vol. 38, pp. 383–412.

Gonzalez, B. M. 1923. Experimental studies on the duration of life. VIII. The influence upon the duration of life of certain mutant genes of *Drosophila melanogaster*. *Amer. Nat.*, Vol. 57, pp. 289–325.

Good, N. E. 1933. Biology of flour beetles, *Tribolium confusum* Duval and *Tribolum ferrugineum* Fab. *Jour. Agric. Res.*, Vol. 46, pp. 327–334.

Greenberg, L. D., and C. L. A. Schmidt. 1936. Studies on the properties of a growth-promoting, factor for *Planaria maculata*. *Jour. Exp. Zool.* Vol. 73, pp. 375–392.

Greenleaf, W. E. 1914. The influence of volume of culture medium and cell proximity on the rate of reproduction of Protozoa. *Proc. Soc. Exp. Biol. and Med.*, Vol. 21, pp. 405–406.

——. 1916. The influence of volume of culture medium and cell proximity on the rate of reproduction in infusoria. *Jour. Exp. Zool.*, Vol. 46, pp. 143–169.

Gregory, Louise H. 1909. Observations on the life history of *Tillina magna*. *Jour. Exp. Zool.*, Vol. 6, pp. 383–431.

Guyénot, É. 1913. Études biologiques sur une mouche *Drosophila ampelophila* Löw. V. Nutrition des adultes et fécondité. *Compt. rend. Soc. Biol.*, T. 74, p. 332.

Hanson, F. B., and Frances R. Ferris. 1929. A quantitative study of fecundity in *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol 54, pp. 485–506.

Harnly, M. H. 1929. An experimental study of environmental factors in selection and population. *Jour. Exp. Zool.*, Vol. 53, pp. 141–170.

——. 1930. A critical temperature for lengthening of the vestigial wings of *Drosophila melanogaster* with sexually dimorphic effects. *Jour. Exp. Zool.*, Vol. 56, pp. 363–368.

——, and Marie L. Harnly. 1935. The effects of temperature on the wings and eyes of the dimorphos vestigial combination in *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol. 72, pp. 75–99.

Harris, R. G. 1923. Control of the appearance of pupa-larvae in paedogenetic diptera. *Proc. Nat. Acad. Sci.*, Vol. 9, pp. 407–413.

Hersh, A. H., and E. Ward. 1932. The effect of temperature on wing size in reciprocal heterozygotes of vestigial in *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol. 61, pp. 223–244.

Holdaway, F. G. 1933. Alteration in the sex ratio in the flour beetle *Tribolium confusum* Duval, following starvation of the newly hatched larvae.

Australian Jour. Exp. Biol. and Med. Sci., Vol. 11, pp. 35–43.

——, and F. Smith. 1932. A relation between the size of host puparia and sex ratio of *Alysia manducator* Pantzer. *Australian Jour. Exp. Biol. and Med. Sci.*, Vol. 10, pp. 247–259.

Hyde, R. R. 1913. Inheritance of the length of life in *Drosophila ampelophila*. *Ind. Acad. Sci.*, Vol. 13, pp. 113–123.

——. 1914a. Fertility and sterility in *Drosophila ampelophila*. I. Sterility in *Drosophila* with reference to a defect in the female and its behavior in inheritance. *Jour. Exp. Zool.*, Vol. 17, pp. 141–171.

——. 1914b. Fertility and sterility in *Drosophila ampelophila*. II. Fertility in *Drosophila* and its behavior in heredity. *Jour. Exp. Zool.*, Vol. 17, pp. 173–212.

——. 1914c. Fertility and sterility in *Drosophila ampelophila*. III. Effects of crossing on fertility in *Drosophila*. *Jour. Exp. Zool.*, Vol. 17, pp. 343–372.

——. 1917. Effect on fertility of crossing closely and distantly related stocks of *Drosophila ampelophila*. *Anat. Rec.*, Vol. 11, pp. 506–507.

——. 1919. Correlation of fertility and fecundity in an inbred stock. *Anat. Rec.*, Vol. 15, p. 355.

——. 1921. A high fecundity record for *Drosophila melanogaster*. *Proc. Ind. Acad. Sci.*, pp. 259–260.

——. 1924. Inbreeding, outbreeding and selection with *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol. 40, pp. 181–215.

Imai, Takeo. 1933. The influence of temperature on variation and inheritance of bodily dimensions in *Drosophila melanogaster*. *Arch. f. Entwicklungsmech. d. Organ.*, Bd. 128, pp. 634–660.

Ingle, L., T. R. Wood, and A. M. Banta. 1937. A study of longevity, growth, reproduction, and heart rate in *Daphnia longispina* as influenced by limitations in quantity of food. *Jour. Exp. Zool.*, Vol. 76, pp. 325–352.

Jahn, T. L. 1934. Problems of population growth in the Protozoa. *Collecting Net*, Vol. 9, pp. 34–41; 47–48.

Johnson, W. H. 1933. Effects of population density on the rate of reproduction in *Oxytricha*. *Physiol. Zool.*, Vol. 6, pp. 22–54.

——. 1936. Studies on the nutrition and reproduction of *Paramecium*. *Physiol. Zool.*, Vol. 9, p. 1–14.

——. 1937. Experimental populations of microscopic organisms. *Amer. Nat.*, Vol. 71, pp. 5–20.

Krafka, J. 1920. Environmental factors other than temperature affecting facet number in the bar-eyed mutant of *Drosophila*. *Jour. Gen. Physiol.*, Vol. 3, pp. 207–210.

Larson, A. O., and C. K. Fisher. 1924. Longevity and fecundity of *Brachus quadrimaculatus* Fab. as influenced by different foods. *Jour. Agric. Res.*, Vol. 29, pp. 297–305.

L'Heritier, P., and G. Teissier. 1933. Étude d'une population de *Drosophiles* en équilibre. *Compt. rend. de l'Acad. des Sci.*, T. 197, pp. 1765–1767.

Loeb, J., and J. H. Northrop. 1917. On the influence of food and temperature upon the duration of life. *Jour. Biol. Chem.*, Vol. 32, pp. 103–121.

Loefer, J. B. 1936. Bacteria-free culture of *Paramecium bursaria* and concentration of the medium as a factor in growth. *Jour. Exp. Zool.*, Vol. 72, pp. 387–407.

Luce, W. M. 1935. Temperature studies on bar-infrabar. *Jour. Exp. Zool.*, Vol. 71, pp. 125–147.

Luck, J. M., Grace Sheets, and J. O. Thomas. 1931. The rôle of bacteria in the nutrition of Protozoa. Quart. Rev. Biol., Vol. 6, pp. 46–58.

MacArthur, J. W., and W. H. T. Baillie. 1929. Metabolic activity and duration of life. I. Influence of temperature on longevity in *Daphnia magna*. *Jour. Exp. Zool.*, Vol. 53, pp. 243–268.

Maclagan, D. S. 1932. The effect of population density upon the rate of reproduction, with special reference to insects. *Proc. Roy. Soc. Biol.*, Vol. 111, pp. 437–454.

Mann, Margaret C. 1923. A demonstration of the stability of the genes of an inbred stock of *Drosophila melanogaster* under experimental conditions. *Jour. Exp. Zool.*, Vol. 38, pp. 213–244.

Mast, S. O. 1917. Conjugation and encystment in *Didinium nasutum* with especial reference to their significance. *Jour. Exp. Zool.*, Vol. 23, pp. 335–359.

McPherson, M., G. A. Smith, and A. M. Banta. 1932. New data with possible bearings upon Robertson's theory of allelocatalysis. *Anat. Rec.*, Vol. 54, *Proc. Amer. Soc. Zool.*, p. 23.

Miner, J. R. 1932. Birth rate and density in a logistic population. *Human Biology*, Vol. 4, pp. 119–120.

Moenkhaus, W. J. 1911. The effects of inbreeding and selection on the fertility, vigor, and sex ratio for *Drosophila ampelophila*. *Jour. Morphol.*, Vol. 22, p. 123.

Moody, J. E. 1912. Observations on the life-history of two rare ciliates, *Spathidium spathula*, and *Actinobolus radians*. *Jour. Morphol.*, Vol. 23, pp. 349–407.

Morgan, T. H. 1912. The masking of a Mendelian result by the influence of environment. *Proc. Soc. Exp. Biol. and Med.*, Vol. 9, pp. 73–74.

——, C. B. Bridges, and A. H. Sturtevant. 1925. The genetics of *Drosophila*. *Bibliographica Genetica*, Vol. 2, pp. 262.

——, and S. C. Tice. 1914. The influence of environment on the size of expected classes. *Biol. Bull.*, Vol. 26, pp. 213–220.

Myers, E. C. 1927. Relation of density of population and certain other factors to survival and reproduction in different biotypes of *Paramecium caudatum*. *Jour. Exp. Zool.*, Vol. 49, pp. 1–43.

Neel, J. 1937. Phenotypic variability in mutant characters of *Drosophila funebris*. *Jour. Exp. Zool.*, Vol. 75, pp. 131–142.

Norris, Maud J. 1933. Contributions toward the study of insect fertility. II. Experiments on the factors influencing fertility in *Ephistia kühniella* Z. (Lepidoptera, Phycitidae). *Proc. Zool. Soc. London*, Vol. 4, pp. 903–934.

——. 1936. Experiments on some factors affecting fertility in *Trogoderma versicolor* Creutz. (Coleoptera, Dermestidae). *Jour. Animal Ecol.*, Vol. 5, pp. 19–22.

Northrop, J. H. 1917a. The rôle of yeast in the nutrition of an insect. (*Drosophila*). *Jour. Biol. Chem.*, Vol. 30, pp. 181–187.

——. 1917b. The effect of prolongation of the period of growth on the total duration of life. *Jour. Biol. Chem.*, Vol. 32, pp. 123–126.

——. 1926a. The influence of the intensity of light on the rate of growth and duration of life of *Drosophila*. *Jour. Gen. Physiol.*, Vol. 9, pp. 81–86.

——. 1926b. Duration of life of an aseptic *Drosophila* culture inbred in the dark for 230 generations. *Jour. Gen. Physiol.*, Vol. 9, pp. 763–765.

Park, T. 1932. Studies in population physiology: the relation of numbers to initial population growth in the flour beetle *Tribolium confusum* Duval. *Ecology*, Vol. 13, pp. 172–181.

——. 1933. Studies in population physiology. II. Factors regulating initial growth of *Tribolium confusum* populations. *Jour. Exp. Zool.*, Vol. 65, pp. 17–42.

——. 1934a. Studies in population physiology. III. The effect of conditioned flour upon the productivity and population decline of *Tribolium confusum*. *Jour. Exp. Zool.*, Vol. 68, pp. 167–183.

——. 1934b. Discussion of Theo. L. Jahn's "Problem of population growth in Protozoa." Cold Spring Harbor Symposium on Quantitative Biology. Vol. 2, pp. 178–180.

——. 1934c. Observations on the general biology of the flour beetle, *Tribolium confusum*. Quart. Rev. Biol., Vol. 9, pp. 36–54.

——. 1935a. Studies in population physiology. IV. Some physiological effects of conditioned flour upon *Tribolium confusum* Duval and its populations. *Physiol. Zool.*, Vol. 8, pp. 91–115.

——. 1935b. Sterilization of *Tribolium* by high temperatures. *Science*, Vol. 82, pp. 281–282.

——. 1936a. Studies in population physiology. V. The oxygen consumption of the flour beetle, *Tribolium confusum* Duval. *Jour. Cell. and Comp. Physiol.*, Vol. 7, pp. 313–323.

——. 1936b. Studies in population physiology. VI. The effect of differentially conditioned flour upon the fecundity and fertility of *Tribolium confusum* Duval. *Jour. Exp. Zool.*, Vol. 73, pp. 393–404.

——. 1937. Experimental studies of insect populations. *Amer. Nat.*, Vol. 71, pp. 21–49.

——. 1938. A note on the size and composition of old *Tribolium confusum* populations. *Amer. Nat.*, Vol. 72, pp. 24–33.

——, and Nancy Woollcott. 1937. Studies in population physiology. VII. The relation of environmental conditioning to the decline of *Tribolium confusum* populations. *Physiol. Zool.*, Vol. 10, pp. 197–211.

Park, Thomas. 1938. Studies in population physiology. VIII. The effect of larval population density on the postembryonic development of the flour beetle, *Tribolium confusum* Duval. *Jour. Exp. Zool.*, Vol. 79, pp. 51–70.

Patten, Mary W. 1911. The life history of an amicronucleate race of *Didinium nasutum*. *Proc. Soc. Exp. Biol. and Med.*, Vol. 18, pp. 188–189.

Pearl, R. 1907. A biometrical study of conjugation in *Paramecium*. *Biometrika*, Vol. 5, pp. 213–297.

——. 1911. Experimental studies on the duration of life. VI. A comparison of the laws of mortality in *Drosophila* and in man. *Amer. Nat.*, Vol. 56, pp. 398–405.

——. 1925. The Biology of Population Growth. *New York* (Alfred A. Knopf).

——. 1927. The growth of populations. Quart. Rev. Biol., Vol. 2, pp. 532–548.

——. 1928. The Rate of Living. Being an Account of Some Experimental Studies on the Biology of Life Duration. *New York* (Alfred A. Knopf).

——. 1932. The influence of density of population upon egg production in *Drosophila melanogaster*. *Jour. Exp. Zool.*, Vol. 63, pp. 57–84.

——. 1937. On biological principles affecting populations; human and other. *Amer. Nat.*, Vol. 71, pp. 50–68.

——. 1938. The Natural History of Population. *London* (Oxford University Press). Pp. xii + 416.

——, Agnes Allen, and W. B. D. Penniman. 1926. Culture media for *Drosophila*. II. A new synthetic media and its influence on fertility at different densities of population. *Amer. Nat.*, Vol. 60, pp. 357–366.

——, and C. R. Doering. 1923. A comparison of the mortality of certain lower organisms with that of man. *Science*, Vol. 57, pp. 209–212.

——, J. R. Miner, and Sylvia L. Parker. 1927. Experimental studies on the duration of life. XI. Density of population and life duration in *Drosophila*. *Amer. Nat.*, Vol. 61, pp. 289–318.

——, and Sylvia L. Parker. 1911. Experimental studies on the duration of life. I. Introductory discussion of the duration of life in *Drosophila*. *Amer. Nat.*, Vol. 55, pp. 481–509.

——, ——. 1912a. Experimental studies on the duration of life. II. Hereditary differences in duration of life in line-bred strains of *Drosophila*. *Amer. Nat.*, Vol. 56, pp. 174–187.

——, ——. 1912b. Experimental studies on the duration of life. III. The effect of successive etherizations on the duration of life of *Drosophila*. *Amer. Nat.*, Vol. 56, pp. 273–280.

——, ——. 1912c. Experimental studies on the duration of life. IV. Data on the influence of density of population on the duration of life in *Drosophila*. *Amer. Nat.*, Vol. 56, pp. 312–321.

——, ——. 1912d. Experimental studies on the duration of life. V. On the influence of certain environmental factors on duration of life in *Drosophila*. *Amer. Nat.*, Vol. 56, pp. 385–398.

——, ——. 1913. New experimental data on the influence of density of population upon duration of life in *Drosophila*. *Amer. Jour. Hyg.*, Vol. 3, pp. 94–97.

——, ——. 1914a. Experimental studies on the duration of life. IX. New life tables for *Drosophila*. *Amer. Nat.*, Vol. 58, pp. 71–82.

——, ——. 1914b. Experimental studies on the duration of life. X. The duration of life of *Drosophila melanogaster* in the complete absence of food. *Amer. Nat.*, Vol. 58, pp. 193–218.

——, ——, and B. M. Gonzalez. 1923. Experimental studies on the duration of life. VII. The Mendelian inheritance of duration of life in crosses of wild type and quintuple stocks of *Drosophila melanogaster*. *Amer. Nat.*, Vol. 57, pp. 153–192.

——, and W. B. D. Penniman. 1926. Culture media for *Drosophila*. I. Changes in hydrogen ion concentration of the medium. *Amer. Nat.*, Vol. 60, pp. 347–357.

——, and L. J. Reed. 1920. On the rate of growth of the population of the United States since 1790 and its mathematical representation. *Proc. Nat. Acad. Sci.*, Vol. 6, pp. 275–288.

Peskett, G. L. 1925. Studies on the growth of yeast. I. The influence of the volume of culture medium employed. *Biochem. Jour.*, Vol. 19, pp. 464–473.

Peterson, W. 1929. The relation of density of population to rate of reproduction in *Paramecium caudatum*. *Physiol. Zool.*, Vol. 2, pp. 221–254.

Phelps, A. 1935. Growth of protozoa in pure culture. I. Effect upon the growth curve of the age of inoculum and of the amount of inoculum. *Jour. Exp. Zool.*, Vol. 70. pp. 109–130.

——. 1936. Growth of protozoa in pure culture. II. Effect upon growth curve of different concentrations of nutrient materials. *Jour. Exp. Zool.*, Vol. 72, pp. 479–496.

Plunkett, C. R. 1926. The interaction of genetic and environmental factors in development. *Jour. Exp. Zool.*, Vol. 46, pp. 181–245.

Poulson, D. F. 1934. Times of development of the two races of *Drosophila pseudoobscura*. *Jour. Exp. Zool.*, Vol. 68, pp. 237–245.

Reed, L. J., and J. Berkson. 1929. The application of the logistic function to experimental data. *Jour. Phys. Chem.*, Vol. 33, pp. 760–776.

Riley, W. A. and L. Krogh. 1922. A coelomic coccidian of *Tribolium*. *Anat. Rec.*, Vol. 23, p. 121.

Robertson, T. B. 1911a. Experimental studies on cellular multiplication. I. The multiplication of isolated infusoria. *Biochem. Jour.*, Vol. 15, pp. 595–611.

——. 1911b. Experimental studies on cellular multiplication. II. The influence of mutual contiguity upon reproductive rate and the part played therein by the "X-substance" in bacterized infusions which stimulates the multiplication of infusoria. *Biochem. Jour.*, Vol. 15, pp. 612–619.

——. 1912. Reproduction in cell communities. *Jour. Physiol.*, Vol. 56, pp. 404–412.

——. 1914a. The nature of the factors which determine the duration of the period of lag in cultures of infusoria. *Australian Jour. Exp. Biol. and Med. Sci.*, Vol. 1, pp. 105–120.

——. 1914b. Allelocatalytic effect in cultures of *Colpidium* in hay infusion and in synthetic media. *Biochem. Jour.*, Vol. 18, pp. 1140–1147.

——. 1914c. The influence of washing upon the multiplication of isolated infusoria and upon the allelocatalytic effect in cultures initially containing two infusoria. *Australian Jour. Exp. Biol. and Med. Sci.*, Vol. 1, pp. 151–175.

——. 1917. On some conditions affecting the

viability of infusoria and the occurrence of allelocatalysis therein. *Australian Jour. Exp. Biol. and Med. Sci.*, Vol. 4, pp. 1–24.

SALT, G. 1936. Experimental studies in insect parasitism. IV. The effect of superparasitism on populations of *Trichogramma evanescens*. *Jour. Exp. Biol.*, Vol. 13, pp. 363–375.

SHAPIRO, H. 1932. The rate of oviposition in the fruit fly, *Drosophila*. *Biol. Bull.*, Vol. 63, pp. 456–471.

SHAW, G. 1932. The effect of biologically conditioned water upon the rate of growth in fishes and amphibia. *Ecology*, Vol. 13, pp. 263–278.

SMITH, G. A. 1932. Strength of culture medium as a factor in fission rate of *Paramecium caudatum*. *Anat. Rec.*, Vol. 54, *Proc. Amer. Soc. Zool.*, p. 100.

STANLEY, W. F. 1935. The effect of temperature upon wing size in *Drosophila*. *Jour. Exp. Zool.*, Vol. 69, pp. 459–495.

STURTEVANT, A. H. 1921. The North American Species of *Drosophila*. *Carnegie Institution of Washington Publications*, No. 301. Pp. 150.

VERHULST, P. F. 1838. Notice sur loi que la population suit dans son accroissement. Corr. Math. et Phys. publ. par A. Quetelet, Vol. 10.

WARREN, D. C. 1924. Inheritance of egg size in *Drosophila melanogaster*. *Genetics*, Vol. 9, pp. 41–69.

WENTWORTH, E. N. 1913. The segregation of fecundity factors in *Drosophila*. *Jour. Genetics*, Vol. 3, pp. 113–120.

WHITE, G. F. 1923. On a neosporidian infection in flour beetles. *Anat. Rec.*, Vol. 26, p. 359.

WINSOR, C. P. 1937. Controlling factors in *Drosophila* population growth. QUART. REV. BIOL., Vol. 12, pp. 348–351.

WOODRUFF, L. L. 1905. An experimental study on the life-history of hypotrichous infusoria. *Jour. Exp. Zool.*, Vol. 2, pp. 585–632.

——. 1911. The effect of excrement products of *Paramecium* on its rate of reproduction. *Jour. Exp. Zool.*, Vol. 10, pp. 557–581.

——. 1925. The physiological significance of conjugation and endomixis in infusoria. *Amer. Nat.*, Vol. 59, pp. 225–249.

——. 1926. Eleven thousand generations of *Paramecium*. QUART. REV. BIOL., Vol. 1, pp. 436–438.

——, and G. A. BAITSELL. 1911. Rhythms in the reproductive activity of infusoria. *Jour. Exp. Zool.*, Vol. 11, pp. 339–359.

——, and R. ERDMANN. 1914. A normal periodic reorganization process without cell fusion in *Paramecium*. *Jour. Exp. Zool.*, Vol. 17, pp. 425–518.

WULZEN, R. 1929. The growth promoting power of egg for planarian worms. *Proc. Soc. Exp. Biol. and Med.*, Vol. 27, pp. 233–234.

YOCOM, H. B. 1928. The effect of the quantity of culture medium on the division rate of *Oxytricha*. *Biol. Bull.*, Vol. 54, pp. 410–417.

THE RELATION BETWEEN DIATOMS AND COPEPODS AS A FACTOR IN THE PRODUCTIVITY OF THE SEA

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THE main features of the food-cycle of the sea have been appreciated in a general way for a considerable period. Recently, however, more precise information has been demanded on the exact interrelation of the various organisms depending upon one another for food. These demands have arisen from the discovery that in the case of various economically important animals a failure in a more or less remote link of certain food chains may be responsible for poor production. Accordingly, the whole sequence of events from the penetration of light energy into the water to the growth and distribution of a succession of food organisms must be scrutinized and properly related before the variations in the productivity of the sea can be understood.

One of the essential links in the main food chain of the sea is the copepod group (cf. Clarke, 1934). The traditional impression of copepod production is that it follows and is dependent upon the growth of diatoms. But in attempting to determine more precisely the relations between copepods and diatoms, recent investigators have proposed certain widely differing theories, all of which need confirmation. A comparison of these theories and of the plankton investigations from which they emanate, will be valuable and, it is hoped, helpful in penetrating further into this important problem.

The season sequence of biological events in the Clyde Sea area has been clearly demonstrated by the work of Marshall, Nicholls, and Orr (1934). These investigators studied the time of appearance and the duration of the diatom flowerings and observed the production of successive generations of copepods. In the case of the copepod, *Calanus finmarchicus*, spawning took place at four periods during the year, namely in March, April, May, and July. Three of these spawning periods coincided roughly with times of diatom maxima in this region. The young of the broods originating in these periods grew successfully to maturity, but the brood which was spawned in April, at a time of diatom scarcity, failed to develop. From this, Marshall, Nicholls, and Orr conclude that the presence or absence of diatoms at the critical period of the early life of the copepod means the success or failure of the brood.

In similar investigations off the coast of Norway, Jacob Sømme (*in litt.*) has not found substantiation for this view. On one occasion he observed that the zooplankton, which usually accompanied or followed the spring flowering of diatoms in this locality, preceded the appearance of the diatoms by three weeks, and yet production was successful. Similarly, observations undertaken off Woods Hole by Clarke and Zinn (1937), although of a preliminary nature, did not indicate any

necessary dependence of copepod production upon diatom abundance. In our case we found that the two successful spawning periods of *Calanus* occurred at times when the diatoms of the region were at a rather low ebb.

Wimpenny (1936), as a result of a series of observations in the North Sea, regards the presence of the biological conditions which occur within a thick patch of diatoms as particularly important for the successful reproduction of zooplankton. Within his area of investigation he found that the greatest numbers of copepods, particularly *Calanus finmarchicus*, were located between the diatom patches—or at least in no relation to them—whereas the eggs of this species were largely concentrated within these patches. Wimpenny points out that the metabolism of the thickly massed plant cells might be expected to produce an environment attractive to animals ready to spawn and favorable for the development of the newly hatched young. (The actuality of this suggestion has not yet been clearly demonstrated, however). In addition, the abundance of nutriment represented by the diatoms themselves might be a necessary circumstance to bring about spawning, and, if a suitable food, would be important for the nourishment of the feebly swimming young. In short, Wimpenny regards patches of diatoms as nurseries for young copepods and feels that the appearance of the diatoms from May to July is responsible for the successful survival of the new broods. The majority of older copepods, however, were to be found outside the diatom zones.

Certain earlier investigators (Johnstone, 1911; Fish, 1925; and Bigelow, 1926) had reported that in their areas, just as in Wimpenny's case, the main copepod population appeared at times and in places in which prominent diatom flowerings were absent. Renewed interest in this apparent reciprocity of abundance has recently been aroused by the ingenious theories of Harvey and of Hardy. In studying the seasonal succession of events in the English Channel off Plymouth, Harvey and his coworkers (Harvey, Cooper, Lebour, and Russell, 1935) observed that for more than seven months of the year the phytoplankton was consistently scarce during periods when zooplankton was abundant, and vice versa. Harvey presents evidence that the "grazing" of herbivorous plankton animals—chiefly copepods—was sufficient to reduce effectively the number of diatoms present. Some species appeared to eat greatly in excess of their needs when diatoms were abundant. The spring outburst of diatoms was believed limited in quantity and in time by the grazing activity of the zooplankton. According to this theory, then, the copepods are thought of as regulating the plant population.

The theory of Hardy (Hardy and Gunther, 1935), although not irreconcilable with the foregoing, gives quite a different complexion to the relation between copepods and diatoms. Drawing on a large mass of data from his survey of antarctic waters, this investigator suggests that zooplankton definitely avoids areas where phytoplankton is thick. This situation would be brought about if, as Hardy assumes, the upward migration of the zooplankton at night were stopped when a dense diatom population was encountered. For, the animals which occurred under diatom patches, being forced to make a longer daily sojourn in the deeper strata, would be carried away by subsurface currents. As a result of this so-called "animal exclusion," the animals and plants of the plankton would become distributed in alternating communities.

As Hardy has pointed out, both this theory and Harvey's hypothesis may be

in operation simultaneously. The zooplankton may be excluded from the centers of the diatom patches because of negative tropistic reactions, but at the same time the animals may reduce the phytoplankton population through grazing around the edges and bottom of the patches. Even if the diatoms are more or less evenly distributed in a given area at the beginning of the productive season, isolated patches would soon be formed by the feeding of local concentrations of zooplankton. The dominant animal type of the region would impress its pattern upon the phytoplankton by "eating holes in it." The distribution of the other species of animals present would then be brought to conform by the action of the "exclusion" process.

In a criticism of these theories, Steeman Nielson (1937) has called attention to a number of cases in which large quantities of both zoo- and phytoplankton exist simultaneously throughout a considerable period. Even in those instances where poor zooplankton has been found in rich diatom zones, or vice versa, a simpler explanation is offered by this author, and one which is particularly apropos for our consideration of causes and limitations of production. It is the time element which Steeman Nielsen shows has been overlooked. He points out that when conditions become favorable for phytoplankton production a very rich population may be established in less than ten days. In the case of the zooplankton, however, not only must the animals mature and spawn following the appearance of suitable conditions, but also a much greater interval must be allowed for development—at least a month for the common copepods. By this time the diatom flowering will probably have passed. Thus arises the impression of an inverse relationship between the animal and plant plankton.

A further complication results from the fact that currents are usually acting on these populations while they are developing. By the time the copepods are fully developed, they may be miles away from the area in which they were spawned. The particularly interesting situation produced by a combination of upwelling and coastal currents off Iceland which is described by Steeman Nielsen, illustrates the necessity for taking the history of the two types of plankton into consideration as well as their distribution at any one time. In general, this investigator concludes that the quantity of zooplankton is directly related to the quantity of phytoplankton, but he emphasizes the fact that because of the slower development of the animals and the effect of currents, a rich growth of diatoms does not necessarity signify the presence in the same locality of an abundant copepod population. The effect of a large phytoplankton production on the zooplankton may appear somewhere else.

This influence of the time element pointed out by Steeman Nielsen is of vital importance, but, in my opinion, its application to the situation has not been carried far enough. An adequate supply of nutriment must be available not only for the maturing parents and for the newly hatched young, but also for each stage of the developing larvae for a considerable time after the spawning period wherever they may drift. In other words, food must be present not alone for the *origination* of the new generation but for its *growth* as well. Careful investigation of the nutritive requirements of copepods has only just begun, but it is reasonable to assume that a considerable supply of food is required at least during the stages in which the animals are increasing in size. Therefore in attempting to explain the distribution of the zooplankton or the success or failure of certain broods on the

basis of nutrition, allowance must be made for the food requirements both during the spawning period and subsequently.

Whether or not food organisms were sufficiently available in any given case could be much more conclusively decided if we knew precisely what food marine copepods eat and how much they need. A review of this subject by Clarke and Gellis (1935) showed that early investigators were divided into those believing that the larger diatoms are the chief source of food and those who feel that other elements of the phytoplankton are more important. Our early experiments at Woods Hole on the nutritive requirements of copepods—particularly of *Calanus*—suggested that microörganisms might play a significant rôle (*loc. cit.*). Further investigation of this point showed that bacteria could be ruled out as a possible food source, but left the question open in regard to other types of nannoplankton (Fuller and Clarke, 1936). Since the growth period of *Calanus* off Woods Hole did not coincide with prominent diatom flowerings, Clarke and Zinn (1937) were forced to conclude either (1) that the small number of diatoms always present as a minimum is sufficient, or (2) that the copepods can build up a reserve during local flowerings sufficient to tide them over the intervening periods or (3) that the numerous nannoplankton organisms are important as a food source.

These possibilities introduce the question of the rate at which food is required by copepods. The nutritional demand of a copepod will undoubtedly differ according to its species, sex, age, etc. Furthermore, if, as seems likely from the reports of observers, copepods are omnivorous, the size and composition of the different types of food organisms must be taken into consideration. Doubt has recently been cast by Lowndes (1935) on the view held heretofore that the feeding of copepods is mainly automatic. But even should feeding prove highly selective, a determination of the amount of food required is essential.

Experiments were carried out at Woods Hole by Fuller (1937) to test the factors influencing the rate at which *Calanus* can remove cells of the diatom *Nitzschia closterium* from the water. He found that of the three temperatures tested, namely 3°, 8° and 13°C, feeding was most rapid at 8°. There was some evidence of a diurnal feeding rhythm with greater activity at night. The fact that change in diatom concentration had no effect on the rate of filtration, and other of Fuller's observations, favored the view that feeding in *Calanus* consists of automatic filtering. Since only about one-half of the organic nitrogen content of *Nitzschia* was found to be digested by *Calanus*, the maximum rate of filtering observed was not sufficiently high to permit a copepod to obtain enough diatoms during the day to satisfy its nutritive requirements as calculated by Marshall, Nicholls, and Orr (1935) on the basis of oxygen consumption. However, studies on the growth of individuals which were supplied with different concentrations of diatoms suggested that less food is needed than these measurements indicated. In addition, Harvey (1937) has just published reports of further tests on the feeding rate of *Calanus* in which much larger species of diatoms (*Lauderia* and *Ditylium*) were used. According to these experiments the copepods can "filter out" the larger cells at rates 5 to 100 times greater than was the case with *Nitzschia*.

In most of these laboratory tests the concentration of diatoms used was considerably higher than that ordinarily found in nature. Although calculations indicate that during naturally occurring maxima

of the *larger* diatoms food could be obtained rapidly enough to permit growth, long intervals usually exist between such flowerings. The smaller and more numerous types of phytoplankton may then be significant. Furthermore, we do not know whether nauplii of copepods are able to take in the more bulky species of diatoms which generally make up flowerings, since the sizes of food particles suitable for the smaller stages of copepods have not yet been adequately investigated. At certain older stages copepods are able to exist for several weeks without eating—according to our experience at Woods Hole, but we certainly should not expect spawning to take place or the rapid growth of the young nauplii to be possible without a rich supply of suitable food.

Questions such as those left unanswered by the foregoing investigations must be settled before we can hope to follow the course of events involved in the food-cycle of the sea, and to appreciate the delicate adjustments underlying production in an oceanic environment. Further work on this problem had best be undertaken either in a relatively isolated body of water or in such a large, homogeneous area that currents are not a serious disturbance. Proper allowance can then be made for the time element in production. Work could advantageously be pursued in semi-enclosed bays or estuaries, and information derived from inland waters would probably be applicable in part, although in all these cases the effect of the bottom must be taken into consideration. Further laboratory experiments on nutrition should be coördinated with these observations at sea in an effort to determine the exact relation of the variable diatom population to the success or failure of the copepod crop.

Presented at the *Symposium on Hydrobiology* held jointly by the American Society of Zoologists and the Limnological Society of America at Indianapolis, Indiana, on Dec. 30, 1937.

LIST OF LITERATURE

Bigelow, H. B. 1926. Plankton of the off-shore waters of the Gulf of Maine. *Bull. U. S. Bur. Fish.*, 40: 1924, Pt. 2, p. 1–509.

Clarke, G. L. 1934. The Rôle of Copepods in the Economy of the Sea. Fifth Pacific Science Congr., *Vancouver, B. C.*, A5. p. 2017–2021.

Clarke, G. L., and S. S. Gellis. 1935. *The Nutrition of copepods in relation to the food-cycle of the sea. Biol. Bull.*, 68: 231–246.

Clarke, G. L., and D. J. Zinn. 1937. Seasonal production of zooplankton off Woods Hole with special reference to *Calanus finmarchicus. Biol. Bull.*, 73: 464.

Fish, Charles J. 1925. Seasonal distribution of the plankton of the Woods Hole region. *Bull. Bur. Fish.*, 41: Doc. 975.

Fuller, J. L., and G. L. Clarke. 1936. Further experiments on the feeding of *Calanus finmarchicus. Biol. Bull.*, 70: 308–320.

Fuller, J. L. 1937. Feeding rate of *Calanus finmarchicus* in relation to environmental conditions. *Biol. Bull.*, 72: 233–246.

Hardy, A. C., and E. R. Gunther. 1935. The plankton of the South Georgia whaling grounds and adjacent waters, 1926–1927. Discovery Reports, 11: 1–456.

Harvey, H. W., L. H. N. Cooper, M. V. Lebour, and F. S. Russell. 1935. Plankton production and its control. *J. Mar. Biol. Ass.*, 20: 407–442.

Harvey, H. W. Note on selective feeding by *Calanus*. J. Mar. Biol. Ass. 22: 97–100.

Johnstone, J. 1911. Life in the Sea. Cambridge Univ. Press.

Lowndes, A. G. 1935. The swimming and feeding of certain calanoid copepods. *Proc. Zool. Soc. London*, Pt. 3, p. 687–715.

Marshall, S. M., A. G. Nicholls, and A. P. Orr. 1935. On the biology of *Calanus finmarchicus*. VI. Oxygen consumption in relation to environmental conditions. *J. Mar. Biol. Ass.*, 20: 1–28.

Steeman Nielsen, E. 1937. On the relation between the quantities of phytoplankton and zooplankton in the sea. *Jour. du Conseil Perm. Intern. pour l'Exp. de la Mer.*, 12: 147–154.

Wimpenny, R. S. 1936. The distribution, breeding and feeding of some important plankton organisms of the south-west North Sea in 1934. Pt. I. *Calanus finmarchicus, Sagitta setosa* and *Sagitta elegans. Fisheries Investig. Great Britain.* Ser. II, 15: No. 3, 1936.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *1901 East Madison Street, Baltimore, Maryland, U. S. A.*

THE PROBLEM OF INTEGRATION

Being a review of Организм как Целое. И. И. Шмальгаузен, Издательство Академии Наук СССР, 1938. [The Organism as a Whole in Its Individual and Historic Development, by I. I. Schmalhausen. *Publishing House of the Academy of Sciences of U. S. S. R., Moscow.* 5 roubles, 50 kop. 144 pp. 1938]

By G. F. Gause, Zoological Institute, University of Moscow.

The problem of organic wholeness has interested theoretical biologists at least since the time of Aristotle, and it also has attracted and still attracts the attention of speculative philosophers. This is indeed a fundamental problem worthy of a close consideration, but this latter came in the past more from theorists than from working laboratory people. The quota contributed in this field by working biologists is relatively small, and such a situation is not very fortunate for the advance of the whole problem. The monograph by Professor Schmalhausen now under review shows how biologists are beginning to win the place that properly belongs to them. He is one of the leading Russian biologists, with wide experience in the fields of comparative anatomy and of *Entwicklungsmechanik*, and in this book he attempts to synthesize many contributions from his laboratory with results that have far-reaching significance. The fact that the book is published in the Russian language and hence is not easily accessible to American biologists makes another justification for our considering here in some detail those parts of the author's argumentation that seem to be particularly suggestive.

The book consists of the following parts: (1) Introduction; (2) Organism as a whole in the individual development; (3) Embryogenesis: phylogeny of embryonic development; (4) Regression: disintegration of correlative systems in the evolution of animals; (5) Progressive evolution: the origin of adaptations; (6) Progressive evolution continued: mutual adjustment of organs.

In the introduction the author points out the significance of the principle of integration, which was realized by Herbert Spencer. Parenthetically, it is just this principle which has been emphasized by Joseph Needham in his recent writings. It is known, on the whole, that evolutionary progress takes the path of increase in the complexity of organization. The whole performing rather general functions differentiates into the parts possessing different specialized functions. These separate parts get their independent functions and are autonomized. However, the proper activity of each separate part is made possible only by a number of functions of general significance. The more a part is specialized the more it depends upon the other parts that guarantee the proper course of the basic living functions of the whole organism, such as respiration, excretion, etc. In other terms all differentiations and specializations are inevitably connected with the advance

in the mutual arrangement of parts, that is to say, with the advance in the level of integration.

The central point of the subsequent discussion which is elaborated by Professor Schmalhausen in much detail is that natural selection represents the factor that contributes to the advance of the level of integration in the process of organic evolution. He starts by consideration of the fact that the integration which finds its expression in the coördinated development of parts in the animal embryo represents an outcome of a long process of historic development. It is indeed true, as numerous experiments of Spemann and of Holtfreter have shown, that at no stage does an organism represent a mosaic arrangement of parts, organs and characters; throughout development it always reacts as an organized whole. In this connection it is significant that the morphogenetic reactions in this developing whole bear a distinct stamp of teleology. For instance, as Spemann has shown, a decrease in size of the embryonic eye-cup brings a corresponding decrease in size of the *Anlage* of the crystalline lens. In other terms various expediently coördinated reactions provide the proper development of the whole embryo even under disturbances of various kinds. An explanation for this fact may perhaps be found in observations of the following type. It appears that the useful restoration of disturbances only takes place when the whole assembly of *somewhat* disturbed parts is normal, that is to say, has behind it a long previous history. If one experimentally brings the developing eye into contact with the ear-capsule, a relation which had never previously occurred in the normal development, the morphogenetic reaction will be distinctly devoid of usefulness and the eye will form an additional retina at the place of contact, as Dragomirow has recently shown in Schmalhausen's laboratory.

The discussion so far outlined deals with the first aspect of the problem of integration: it treats the integrated behavior of individual development and of individual responses to environmental effects. In his attempts to explain this integration by the principle of natural selection of appropriate reaction mechanisms, Professor Schmalhausen comes to some generalizations concerning the phyletic accumulation of what he calls reaction mechanisms of general significance. A useful response upon the modifying effect of environment, which implies a number of coördinated physiological processes, has at its bottom a specific reaction mechanism which has been gained in the process of natural selection at some time in the past and has not since been lost. As Schmalhausen himself says:

> The useful reorganization in the structure of a bone with the change in the character of load, the strengthening of a muscle with the increased work, or the increase of a nervous centre with the expansion in the region of innervation must be evaluated as adaptive modifications of the most general character. The reaction mechanisms of this kind, having once been acquired, do not disappear subsequently insofar as they do not lose their importance (certainly with the exception of some special cases of acquiring sedentary or parasitic habits of life).
>
> The reaction mechanisms of general significance are apparently relatively complicated and do not appear often in evolution, but they fundamentally enter the mechanism of individual development of whole phyla and perhaps of even greater branches in the kingdom of living creatures. Such is, for instance, the significance of adaptive modifications of muscles with differences in their work, the mechanism of which was probably acquired at the very beginning of evolution of the muscular system of vertebrates, or perhaps even earlier.

The adaptive modifications represent only one aspect of the integrated behavior of the individual, and the whole originality of Professor Schmalhausen's book lies perhaps in the rôle that he ascribes to these modifications in the process of further evolution. He believes them to be of importance in determining the path of evolution and particularly responsible for the integrity of its product. But to picture this process as naïvely as the followers of Lamarck have done is certainly no longer possible today because it is proved by genetic science that the acquired characters are not transmitted to offspring, and Schmalhausen is perfectly aware of this fact. Let us consider his attempt to grasp the whole situation from the viewpoint of the principle of natural selection.

It is best to start from the fact that there exists a proved parallelism of nonhereditary and of hereditary responses in

the geographic variation of plants and animals. In many animals a decrease of temperature during individual development causes a non-hereditary increase in size, and an analogous hereditary increase in size is usually recorded in comparing the northern varieties of the same animal with the southern ones. Numerous examples could be cited which conform to this rule. An adequate way for its explanation may perhaps be found in the well-known observations of Goldschmidt, who recorded a parallelism in somatic expression between hereditary mutations and non-hereditary modifications induced in *Drosophila* by high temperature, which he calls *phenocopies*. It is on the whole probable that an organism reacts to the change of environment first by non-hereditary adaptive modifications, the very possibility of which is caused by previous selection of appropriate reaction mechanisms. However, these modifications become soon substituted in population by their hereditary analogues. Schmalhausen reverses here the terminology of Goldschmidt and calls these analogues *genocopies*. The reasons for such substitutions are the following. If a non-hereditary modification is adaptive, i.e., favorable for survival, an hereditary mutation with analogous somatic effect will be at least not thrown out of the population. But there are reasons to believe that the appearing mutations could in some respect be even more advantageous than the modifications which they duplicate, as far as the somatic effect and the ultimate survival are concerned. For instance, the adaptation required could by means of mutations be made perhaps more radical. Every slight advantage of mutations over modifications in selection will be sufficient to cause the substitution in population of the latter by the former.

The conception of evolution arrived at in the course of this reasoning is extremely interesting, and it appears as if adaptive non-hereditary modifications are preparing the way for the subsequent course of evolution. There are certainly many implications in this conception, but it seems to the reviewer that they need to be made clear by further experimental work that is still lacking.

In concluding it is to be pointed out that the book under review is by no means an exhaustive treatise on the principles of organic integration. Rather it is an attempt to approach some selected aspects of these principles by a biologist with Darwinian philosophy. There can be no question that this attempt is stimulating for further research.

BRIEF NOTICES

EVOLUTION

EVOLUTION. *Essays on Aspects of Evolutionary Biology Presented to Professor E. S. Goodrich on His Seventieth Birthday.* *Edited by G. R. de Beer. Oxford University Press, New York; Clarendon Press, Oxford.* $5.00. $8\frac{3}{4}$ x $5\frac{1}{2}$; viii + 350; 1938.

This commemorative volume bears witness to the esteem in which one of the leading biologists of the British Isles is held by his contemporaries. The caliber of the nineteen essays by as many contributors speaks as loudly of this esteem as the three page bibliography speaks of Dr. Goodrich's own contribution to modern evolutionary biology.

No one today questions that evolution takes place. There is some disagreement as to how it may take place, but the greatest disagreement will be found as to when it takes place. Just how different from the type a variation must become in order to be considered a new species is a question to which no satisfactory answer can be given. Yet two of the contributors, J. B. S. Haldane and O. W. Richards, have undertaken to give it a partial answer, and have succeeded in throwing light on it, and it is also touched upon by G. R. de Beer, who has also written the preface to the volume.

W. A. Tucker discusses the evolution of the birds. The older theory was that the avain ancestor was an arboreal reptile —that the wings were used for climbing before flying. A later theory made the ancestor cursorial rather than arboreal—

with wings used originally for running. Among birds now extant we find wings used in all three ways—the hoatzin uses its wings for climbing, while the penguin runs on all fours with a trotting motion, the wings striking coördinately with the feet on the opposite side. Mr. Tucker is inclined to agree with the older view. Now the penguin is a rather highly specialized bird, while it is generally believed that the hoatzin is the sole survivor of a primitive type, so that these two birds give much aid and comfort to Mr. Tucker's theory. It is therefore surprising that he makes no mention of them in developing it.

The origin of the crustacea from the trilobites is ably discussed by Walter Garstang, and in other essays the bony fishes, the echinoderms, and the parasitic worms come in for discussion. There is a complete index, but only three illustrations.

MORE DIFFICULTIES OF THE EVOLUTION THEORY *and a reply to "Evolution and Its Modern Critics."*

By Douglas Dewar. Thynne and Co., London. 8s. 6d. 8½ x 5½; [12] + 206 + [9]; 1938.

In this sequel to his *Difficulties of the Evolution Theory*, Dewar makes a reply to A. Morley Davies who, in a recently published book entitled *Evolution and its Modern Critics*, has tried to meet the difficulties set forth by Dewar in the earlier work. So the bickering and passing the buck have extended through three successively published volumes, and inasmuch as concrete proofs are forthcoming from neither side, it is entirely probable that the squabble will continue through an indefinite number of future publications. "He (Davies) asserts positively that in the past an amphibian became gradually transformed into a reptile and calls upon me to prove that this did not happen. I submit that the burden of the proof lies with him who asserts". Here Davies cannot prove a point and Dewar cannot disprove it, so they wrangle on indefinitely.

Dewar presents, as in his previous publications, much rational evidence against evolution by natural selection, but, as usual, fails to give the slightest evidence in favor of special creation. The most interesting part of the book is a chapter entitled "Difficulties presented by some instincts", in which the author describes the process of nest-building of the Indian tailor bird, the oriole and the weaver bird—a topic on which his wide field experience as an ornithologist has well qualified him to write.

The volume contains an index, a glossary and a few charts and drawings.

THROUGH THE GREAT ARID FILTER (*Man's Drift to Europe*).

By A. J. McInerny. Obtainable from the author, A. J. McInerny, % Printerdom, Otley, Yorks, England. 2s. 8⅜ x 5½; 46; 1938 (paper).

This interesting book stresses the importance of deserts in the evolution of man, and particularly of the white race. It is a difficult book because badly organized and badly written. The central thesis is indicated in the following passage, perhaps as well as in any that could be chosen:

> Thermal Aridity is the *Alma Mater* under whose care the intellectual development of man has been fostered. It was during the times of the slowly disappearing Wurm Ices that the lowly ancestor of man, who had been struggling during the whole Pleistocene period to fit himself for it, was to receive the first earnest of a new intellectual *regime* destined to attain fruition, in the West at least, around the Caspian shores and in North Africa. In decrying the deserts, it is useless to lose sight of the necessary elements which we find only in those sun-scorched regions. A place has to be provided, in the economy of our existence, for these indispensable cleansers of our atmosphere.

ELIMINATION UND SELEKTION. *Eine Untersuchung über Merkmalsprogressionen bei Tieren und Pflanzen auf genetisch- und historisch-chorologischer Grundlage.*

By W. F. Reinig. Gustav Fischer, Jena. RM. 8. 10 x 6¾; viii + 146; 1938 (paper).

Reinig attempts to arrive at a uniform conclusion for the northern hemisphere, as to the origin and distribution of plant and animal species due to changes in geological periods. He especially stresses the glacial and post-glacial changes as resulting in migrations. There is considerable amount of speculation as to the part played by these factors in the process of elimination and selection.

A number of maps and tables are inserted to illustrate the author's points, and the volume is indexed.

GENETICS

STRUCTURAL VARIATIONS OF THE HUMAN IRIS AND THEIR HEREDITY *with Special Reference to the Frontal Boundary Layer.*

By Viggo Eskelund. Nyt Nordisk Forlag, Arnold Busck, Copenhagen; H. K. Lewis and Co., London. 21s. net. 10 x 7½; 242 + [1]; 1938 (paper).

Although such notorious families as the Jukes and Kallikaks have shown a rather wanton broadmindedness concerning illegitimate progeny, society, in general, adopts a far more censorious attitude toward *filii nulli*. Since blood-type tests serve only to exclude possible fathers, extensive anthropological and hereditobiological examinations have been tried for a more desirable result; that is, proof of the actual identity of the father. "von Verschuer now considers himself able to exclude paternity with certainty in 14 per cent of cases, with great probability in a further 14 per cent and can indicate the probable paternity in 56 per cent, while it is only in the remaining 16 per cent that he cannot decide either for or against possible paternity."

In connection with the studies on paternity, there has been much research on the inheritance of the pigmentation of the iris, but the structure of the iris and its inheritance have, with the exception of a few papers by Josef Weninger, been little investigated. Eskelund presents his extensive study on the structure of the human iris, its frontal aspect, and its structural variations and their heredity. In addition to the chapter dealing with photographic technique, schemes of classifications of the variations of the iris, frequency and mutual relations of the variations, relations between structure and pigmentation of the iris, width of the cornea, the inheritance of structural variations of the iris and of variations of the cornea are discussed. The author's study on inheritance was based on 15 married couples, their 44 children, and 14 children of whom only one parent was examined. Included in this investigation are the results of the author's researches on iris and corneal variations in 5 sets of twins, three of which were supposedly uniovular and two binovular.

There are many full page photographs of the human eye, each accompanied by a formula giving the exact structure of the iris of the particular case. Also available in this book are the detailed reports of the cases studied.

GENETICS. *An Introduction to the Study of Heredity. Fourth edition.*

By Herbert E. Walter. The Macmillan Co., New York. $3.00. 8½ x 5¾; xvii + 412; 1938.

The advance that has been made in genetic science since the appearance of the third edition of this work eight years ago has made the preparation of a new text imperative. The present work, however, cannot be called a revision—in fact, the author himself tells us that it is a new book under an old title. The student who has become used to the predecessors of this volume is likely to find nothing familiar to him except the name and the delightful sense of humor that continually crops out in unexpected places; but he is likely to regret the omission of the reference to the pied piper in the discussion of Weismann's family of 1592 rats.

The most conspicuous departure in the present text is the inclusion of numerous portraits of the founders of and contributors to the science of genetics from Koelreuter in the 18th century to the present day, which contribute to its human interest. Less obvious but more important differences are the inclusion of a lucid and well written chapter on the

fundamentals of the biometrical method and a detailed description of chromosome maps of *Drosophila* from T. H. Morgan. Unfortunately the inclusion of so much new material has forced the exclusion of much that was in the earlier editions and a situation is precipitated that reminds the reader of the snapping turtle, which, in order to withdraw its forequarters into its shell is compelled first to extrude its hindquarters. The student who acquires this book is advised not to dispense with his old copy. The bibliography covers 6 pages and the index 10.

THE CHEMISTRY OF THE INDIVIDUAL. *Being the Thirty-eighth Robert Boyle Lecture Delivered before the Oxford University Junior Scientific Club on June 12, 1936.*

By J. B. S. Haldane. Oxford University Press, New York. 40 cents. 8½ x 5½; 17; 1938 (paper).

This scholarly work by Professor Haldane brings to light a case which has been proved for dwarf mice, where there is a recessive gene affecting production of anterior pituitary hormones. Such animals are sterile and do not live long under ordinary conditions. In the case of Sebright fowls, there is no gene affecting the rate of production of hormones, but one which affects the threshold of the epidermis to hormones. In general, the author has given much convincing evidence that genes operate all along the line of development, and can affect a certain result in various ways.

"It is better," in the words of the author, "to adopt a more physiological point of view and say that such and such a normal gene determines not a unit character, but a unit process, or a unit chemical reaction; that is to say, one of those which leads up to the development of a given character." Emphasis is placed upon the fact that genetics is now a "physiological" study, and links into many fields, including endocrinology, biochemistry, embryology, immunology, and cellular physiology.

THE STUDY OF HEREDITY.

By E. B. Ford. Thornton Butterworth, London. 2s. 6d. net. 6½ x 4¼; 256; 1938.

The principles of genetics are clearly and competently discussed in this booklet written especially for the layman. The subject matter is presented in the usual form. There is first of all a brief description of the chromosomal mechanism and of Mendel's theory followed by chapters on the heredity of sex, variation, evolution and on some inherited characteristics observed in man. The illustrative examples from observational and experimental data have been very well chosen but the author has apparently been unable to avoid the use of a technical terminology. On the whole, the book deserves praise as a condensation of the subject to aid the undergraduate student in biological sciences rather than as a successful effort at popularization. In this respect, the value of the book would have been increased considerably by the use of pictures and drawings. There is a glossary, an index and a very sketchy bibliography.

THE MEASUREMENT OF LINKAGE IN HEREDITY.

By K. Mather. Chemical Publishing Co. of New York, New York. $1.75. 6½ x 4; ix + 132; 1938.

This is an excellent small book for the geneticist. However, even with the introductory chapter which explains briefly the methods involved, a non-mathematical reader would be unable to get the full benefit of the discussion. Chapters are devoted to the ways of estimating the number of individuals necessary in planning an experiment, in detection and estimation of linkage, and in testing for heterogeneity. The χ^2 test of significance and the method of maximum likelihood are stressed in treating the above problems, although other statistical methods are suggested. The author uses these same techniques in dealing with disturbed segregations involving coupling and repulsion. Human hereditary analyses are complicated by the small size of families and lack of information concerning the

genetical constitution of the matings. Brief treatments of these limitations are presented for human single factor segregations and linkage.

Throughout the pages numerous examples demonstrate the points in question. The final chapter consists of formulae, symbols, and short tables to facilitate calculations.

GENERAL BIOLOGY

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ending June 30, 1937.*

Smithsonian Institution. U. S. Government Printing Office, Washington. $1.00. 9⅛ x 5¾; xv + 580; 1938 (paper).

For the benefit of those, who, with a general interest in science, are unacquainted with these annual reports, we strongly recommend the expenditure of one dollar for this volume which is heavy and unwieldy to handle and gives (in its external appearance) every indication of being dull. The first part *is* mostly dull, dealing, as reports do, with finances, numbers of visitors to the different departments (U. S. National Museum, Freer Gallery of Art, National Zoological Park, etc.), lists of staff members, donors of gifts, etc. However, even here we find much that is interesting concerning Mr. Mellon's fine gift to the nation, recent acquisitions of the Freer Art Gallery—and some will even enjoy glancing through the list of animals in the National Zoo.

On page 127 begins the general appendix. Under the heading "Advertisement" we read the following:

> It has been a prominent object of the Board of Regents of the Smithsonian Institution from a very early date to enrich the annual report required of them by law with memoirs illustrating the more remarkable and important developments in physical and biological discovery, as well as showing the general character of the operations of the Institution; and, during the greater part of its history, this purpose has been carried out largely by the publication of such papers as would possess an interest to all attracted by scientific progress.

It is this particular section of the report that we wish to call attention to. Unfortunately, it is impossible to mention all of the interesting papers which Dr. Abbott, the Smithsonian Secretary, has herein assembled (a total of 28); only a few of biological interest can be listed. J. H. Kempton contributes a paper on Maize—our heritage from the Indian (30 plates); Leonard P. Schultz writes of the breeding habits of the salmon and trout (5 plates); George S. Meyers on Fresh-water fishes and West Indian zoogeography (3 plates); Walter C. Alvarez on The emergence of modern medicine from ancient folkways (1 plate); William Robinson on The healing properties of allantoin and urea discovered through the use of maggots in human wounds; Wilmot A. Bradley on The biography of an ancient American lake (4 plates). All of the articles are well written and are comprehensible to the layman. The photographic plates are well chosen and beautifully executed. We think that all general libraries, and particularly high school libraries, should give these annual reports a prominent place on their shelves.

A LABORATORY AND FIELD GUIDE TO BIOLOGY.

By Samuel H. Williams. The Macmillan Co., New York. $1.25. 6 x 4½; xxv + 130; 1938.

A MANUAL FOR THE BIOLOGY LABORATORY. *By Perry D. Strausbaugh and Bernal R. Weimer. John Wiley and Sons, New York; Chapman and Hall, London.* $1.75. 11 x 9; ix + 183; 1938 (paper).

Professor Williams feels that present methods of teaching biology are all right insofar as the student is preparing for medicine or biological research, but that those who select biology as a cultural subject will find more interest in the study of living organisms in their natural habitats. Consequently this book was prepared to provide a working method for biology study in the field. It consists of a series of exercises which include directions for the student to follow. The exercises are concerned with the various

groups of animals and plants commonly found in most areas.

The *Manual*, besides giving the usual instructions for laboratory dissection and observation, also includes space where the student may draw what he sees. Some of the drawings have already been started for him so that all that is required is the addition of a few lines to complete them.

LA VIE DANS LA RÉGION DÉSERTIQUE NORD-TROPICALE DE L'ANCIEN MONDE. *Société de Biogéographie VI.*

By L. Aufrère, F.-S. Bodenheimer, A. Chevalier, L. Chopard, L. Emberger, H. Foley, H. Gauthier, L. Joleaud, Ch. Killian and D. Féher, R. Maire, Th. Monod, P. de Peyerimhoff, A. Reymond, L.-G. Seurat, P. Teilhard de Chardin, B.-P. Uvarov, B. Zolotarevski and M. Murat. Paul Lechevalier, Paris. 175 francs. 10 x 6⅝; 406; 1938 (paper).

This volume presents twenty separate papers by eighteen different authors on all phases of life in the desert regions of the old world. Four of the papers describe the formation and extent of the deserts of Asia and Africa. The others deal with general biology, soil biology, flora, fauna, and human pathology of the desert regions. Fundamental findings seem to indicate that the desert flora is, in large part, made up of the survivals of the old xerophytes of the tertiary. The fauna of the desert differs in general from that of regions of more temperate climate and normal rainfall in being especially adapted to resist excess heat and evaporation, and in having a life cycle adapted to the radically different yearly cycle of environmental conditions.

A summary chapter by H. Monod is included, giving a simple résumé of the separate papers.

RATIONALE BIOLOGIE UND IHRE KRITIK. (*Eine Auseinandersetzung mit dem Vitalismus H. Driesch's*).

By Eugen Heuss. Verlag von S. Hirzel, Leipzig. RM. 6. 9¾ x 6⅝; ix + 192; 1938 (paper).

This is a rather difficult philosophical treatise on the fundamentals of theoretical biology. Unfortunately, the style of writing lacks clarity, thereby adding to the difficulties of understanding the author's ideas. It deals especially with Driesch's theory of vitalism and his doctrine of entelechy by which he means a specific biological agent which is alleged to form the world of organism *a priori* and independent of other experience. Therefore biological knowledge is a knowledge *sui generis* and cannot be explained only as a kind of life mechanics. There is an appendix on Kant's discussion of vitalism.

A SELECTED BIBLIOGRAPHY ON MANAGEMENT OF WESTERN RANGES, LIVESTOCK AND WILD LIFE. *U. S. Department of Agriculture. Miscellaneous Publication No. 281.*

By F. G. Renner with the assistance of Edward C. Crafts, Theo C. Hartman and Lincoln Ellison. Government Printing Office, Washington. 45 cents. 9¼ x 6; ii + 468; 1938 (paper).

This bibliography includes the more important references to publications relating to western grazing lands of the United States—the domestic livestock, wild life and plants—comprising seventeen states and Alaska, with the exclusion of eastern Texas and eastern Oklahoma. It is believed to be complete through 1933 and some of the more important references from 1934 to 1937 have also been included. The sectional headings are distinctly defined as to the scope of the material and cross references are listed at the end of each section. An author index is appended. A very valuable contribution.

DEUTSCHES BIOLOGEN-HANDBUCH. *Eine Übersicht über die deutschen Biologen, die biologischen Institute und Organisationen. 2. Auflage.*

Edited by Ernst Lehmann and Otto Martin. J. F. Lehmanns Verlag, München and Berlin. RM. 8; for members of the Deutscher Biologen-Verband, RM. 7. 8⅛ x 5⅝; viii + 261; 1938.

In addition to bringing this book (first edition noticed in Q. R. B. Vol. 10, No. 4) up-to-date with reference to changes in personnel the editor has expanded it to include all biologists working in institutions, schools, publishing houses and newspaper offices, museums, etc. in Germany; also a list of biological societies in that country. Former Austria is included. A few German societies and investigators in other countries are likewise mentioned.

BIBLIOGRAPHIA BIOTHEORETICA *quam ediderunt qui praesunt Fundationi cui nomen est "Prof. Dr. Jan van der Hoeven-Stichting voor theoretische biologie van dier en mensch, verbonden aan de Rijksuniversiteit te Leiden". Serie C. Titulos Librorum, etc. Annorum MCMXXV, MCMXXVI, MCMXXVII, MCMXXVIII, MCMXXIX, collected and edited by J. H. Diemer and C. J. van der Klaauw.*

Edited by C. J. van der Klaauw, J. A. J. Barge and Ad. Meyer. E. J. Brill, Leiden. 11 guilders. $9\frac{7}{8}$ x $6\frac{1}{2}$; xi + 236; 1938.

A list of 4802 titles in the field of theoretical biology published during the years 1925–29. The bibliography (divided into 21 categories) is intended for all workers interested in the theoretical side of their branch of science; namely, in the notions, conceptions, mathematics, and general theories in the field of biology or medicine. It is planned to begin the publication of annual bibliographies of this kind from 1935 on.

A LABORATORY MANUAL OF GENERAL BIOLOGY. *Second Edition.*

By E. Grace White. C. V. Mosby Co., St. Louis, Mo. $1.75. $10\frac{1}{2}$ x $7\frac{3}{4}$; 262; 1938 (paper).

The present laboratory guide (cf. Q. R. B., Vol. 8, No. 4 for review of first edition) follows the changes and additions in the second edition of the author's *Textbook of General Biology*. Among these changes should be especially mentioned the addition of the material on the dogfish, and the section on field study.

SIR JOSEPH BANKS ISLANDS. *Part I. Reports of the McCoy Society for Field Investigation and Research. No. 2.*

McCoy Society. Reprinted from the Proceedings of the Royal Society of Victoria, Vol. 50, Pt. II. $9\frac{3}{4}$ x $6\frac{1}{8}$; 303–413; 1938 (paper).

A list of plants and animals and their distribution found in a group of about 20 islands, islets and reefs lying eastward of Louth Bay in Spencer Gulf, South Australia.

THE UNIVERSITY OF COLORADO STUDIES, *Volume 25, Number 2. Papers concerning Junius Henderson, Curator of the University of Colorado Museum from 1900 to 1933.*

University of Colorado, Boulder, Colorado. $1.00. 10 x $6\frac{3}{4}$; 117–160; 1938 (paper).

HUMAN BIOLOGY

KNOWLEDGE AND SOCIETY. *A Philosophical Approach to Modern Civilization.*

By G. P. Adams, W. R. Dennes, J. Loewenberg, D. S. Mackay, P. Marhenke, S. C. Pepper and E. W. Strong. D. Appleton-Century Co., New York and London. $2.75. $8\frac{3}{4}$ x 6; xiii + 417; 1938.

Some time ago a critic whose intellect was more brilliant than profound compared the metaphysician to a blind man in a dark room trying to catch a black cat that wasn't there. If this idea of what constitutes metaphysics is more prevalent than it should be the metaphysicians themselves are largely responsible, for the esoteric nature of much metaphysical literature is due in no small degree to the philosophical jargon in which it is couched.

The collaborating authors of the work under consideration have avoided this pitfall. In some places their drift is hard to catch, but this is generally due to the profundity of the thought rather than to its concealment under an efflorescence of verbiage. The result is that this work misses being a really great book by the narrowest of margins.

It is not likely that anyone will accept

all the conclusions, or even all premises from which the authors start. Consider, for instance, the conception of the nature of law promulgated by the authors, upon which their answer to the question as to freedom of the will is largely based. Law, they tell us, is a term used to designate two fundamentally different things. Natural law has no more in common with human law than the stock that grows in our gardens has with the stock that is traded on the floor of the bourse. Natural law is descriptive, human law is prescriptive. The one tells how objects behave, the other how persons ought to behave. The one cannot be broken, the other may be.

Over a generation ago this conception of law was shown by Pearson in *The Grammar of Science* to be altogether erroneous. A law in any case is a descriptive formula. The Natural Law of gravitation does not tell us objects fall; it tells us how objects ought to fall if their behavior is to be consistent with that of similar objects which have been observed to fall in the past. Similarly with human law. The first human laws were taboos. First a custom was established, then laws were formulated to define the custom and forbid deviation from it. For this reason primitive legal codes such as the decalog are largely prohibitory.

Does this interpretation of law invalidate the conclusions of the authors as to freedom of the will? By no means. Kepler's laws of motion are formulated, although the premises on which they are based contained two serious errors—which neutralized each other. Most philosophers accept the doctrine of freedom on pragmatic evidence—the will feels free. Pragmatic evidence is not always the best kind, but in this instance no other evidence is available—there can be no empirical method of demonstrating freedom of the will. If having made a choice we could then turn backward the wheel of time in its flight to the instant when the choice was made, and then make a different choice, freedom would be demonstrated, but because the wheel of time cannot be so turned back the making of a choice precludes the possibility of demonstrating that an alternative choice was possible. When an individual makes different choices under circumstances that appear to be the same it may well be that some unnoticed factor that differed in the two instances conditioned the choices. Therefore the question "Is the will free?" is hardly a legitimate one, for it postulates the availability of evidence that we believe to be non-existent. It would have led to more satisfactory philosophical results had freedom been accepted as a postulate in which case the arguments pro and con concerning mechanism, vitalism, mysticism, rationalism, and theism might have been made more convincing.

The book is divided into two parts—the first dealing with absolute and the second with applied philosophy. The opening chapters deal with common sense and the scientific method, and are well thought out and well expressed.

In these days when all philosophies of economics, politics, and sociology are subject to change without notice the value of such a work as this is inestimable to those who find it difficult to think through to a conclusion the conditions that confront us. To such persons no recommendation of this work can be too high.

AUDUBON THE NATURALIST. *A History of his Life and Time. Second Edition.* *By Francis Hobart Herrick. D. Appleton-Century Co., New York.* $6.00. 8¾ x 6; vii + 500; 1938.

The present year saw the centennial anniversary of the publication of Audubon's "Birds of America," and it is therefore appropriate that a new edition of the classical biography of this early figure in American ornithology and mammalogy should appear. The first edition of this work appeared twenty years ago and so carefully had it been compiled that no serious alterations in the text have been involved, but it has been necessary to expand the introductory portions owing to the recent discovery by the author of some documentary evidence bearing directly on the mystery of Audubon's birth, a matter about which Audubon himself told many conflicting stories. Dr. Herrick believes that this was done to conceal

the illegitimacy of his birth, and it must be confessed that the physician's bill, the certificate of baptism, the power of attorney given by Audubon to his brother-in-law in later years, and the efforts of relatives to break his parents' wills, taken together seem rather convincing.

The rumor of the identity of Audubon with the dauphin who was to have been Louis XVII which has become current in recent years seems to rest on no evidence except that they were of substantially the same age, and that Louis made his exit from history at about the same time Audubon entered it. It may be dismissed at once, for the researches of Watson Dewees indicate that Stephen Grellet positively identified Eleazer Williams as the dauphin in the presence of John Collins. But, as Dr. Herrick has remarked, Audubon's life was so romantic that it needs no bolstering up by any rumor connecting him with royalty. Born in Hispaniola; studying painting under David in Paris and Sully in Philadelphia; making his home successively in Pennsylvania, Ohio, Kentucky, Louisiana, New Jersey, and New York; becoming by turns a miner, a merchant, and a miller, and failing at all three occupations; collecting natural history specimens throughout the United States as then constituted, and the independent republic of Texas as well; supporting himself as he went by giving lessons in drawing, painting, dancing, and playing the flute and violin, while his wife kept the home fires burning and brought up the children; finally achieving recognition in England whither he had gone to take orders for the *Birds of America*; enumerating among his friends Thomas Say, Lucien Bonaparte, Titian Peale, Daniel Boone, Reuben Haines, Richard Harlan, Thomas Nuttall, and John Townsend, and among his acquaintances if not his friends George Ord, Isaac Lea, and Gerard Troost—his life was even more interesting, as he himself wrote, than that of his father.

Yet to the present reviewer there are two figures in the background whose lives seem more appealing in their individualities than that of the propositus, and Herrick is to be thanked for the wealth of biographical material which he has accumulated about them. They are Alexander Wilson, who was painting birds within a few miles of Audubon in Philadelphia, although neither of them knew it until they met by accident in Louisville, Kentucky many years later; and that erratic and incomprehensible talent Rafinesque, who so narrowly escaped being a genius, and whose hybrid ancestry surpassed even that of Lafcadio Hearn.

Herrick places the responsibility for keeping Audubon out of the Academy of Natural Sciences squarely upon George Ord. But he makes no mention of the part played by Gerard Troost, nor does he mention the fact that Audubon was eventually admitted after the death of Troost.

Those who read biographies because they enjoy the lives of picturesque characters of the past will be delighted with this work, for it is fascinating reading. But apart from this it is a work of scientific value, as its 16 pages of chronology, its 18 pages of index, its 61 pages of bibliography, its 87 pages of miscellaneous appendices, and its 116 well executed illustrations all bear witness.

OCKHAM. *Studies and Selections.* *By Stephen C. Tornay. Open Court Publishing Co., LaSalle, Ill.* $1.75. $7\frac{3}{4}$ x $5\frac{3}{8}$; viii + 207; 1938.

The author of this work has attempted to compress an immense quantity of material into a lamentably small space and to do so has resorted to extensive documentation. The book would have been more readable if it had been expanded and the documented material represented by incorporations into the text.

An indispensible prerequisite to an understanding of Ockham's philosophy is a thorough familiarity with the vocabulary of mediaeval metaphysics, and unfortunately but few readers are so prepared. Many will feel, on essaying this book, that like Polonius they are reading "words, words, words." What, for instance, can the average reader make of such a statement as this: "Logic, which used to teach *vere loqui* began after its alliance with grammar to teach *recte*

loqui."? Are we to understand by the terms logic and grammar what passes under these names today, or are we to accord them the meaning they had in the classical *Trivium*?

This is a difficult point to decide. The three subjects in the *Trivium* were logic, gammar, and rhetoric, which designated respectively the art of thinking, the art of self expression in writing, and the art of self expression in speaking. The mastery of these three subjects would be considered a liberal education even today. But Ockham lived in a critical period. Education was in a state of flux. Established methods of expression were undergoing deep seated changes as the result of the breaking up of classical Latin into the Romance languages, and even philosophical Latin, though a dead language, was still undergoing the deterioration so much lamented by Boethius (and which continued long after Ockham's day—compare the Latin of Linnaeus with that of Thomas Aquinas or Cicero). The exactitude of expression of classical Latin began to disappear at the time of the barbarian invasions. Partly because Ockham insisted on exactitude in his definitions of terms the author regards him as the founder of modern scientific method, and intimates that without him there might have been no Leonardo da Vinci, no Roger Bacon, no Copernicus, Descartes, Galileo, or Newton.

And yet, Ockham was strangely inconsistent. As a nominalist he shared with Democritus and Lucretius and the other atomists a belief in the immutability of types, but he also believed in a formless primordial substance, from which all secondary substances were derived by the assumption of form by its ultimate particles—a belief which suggests not only the modern electronic theory, but also that of the alchemists concerning the transmutation of the base metals into gold.

There is very little of a biographical nature set out in this book—for very little is known of the life of Ockham. The date of his birth is uncertain, but it occurred early in the 14th century. It is known that he joined the Franciscan order and so brought down upon his head the wrath of Pope John XXII for which he suffered incarceration at Avignon. After four years he escaped and then established himself at Munich under the protection of Louis the Bavarian. Here he turned his talents from philosophy to sociology and politics, and with his pen attacked the degeneracy of the papacy, the abridgment of free speech, the use of violence even in a good cause, and capital punishment. He died in 1349 a victim of the Black Death.

It is difficult to appraise the character of such a man. He is revealed to us chiefly through his pen, and perhaps the more important part of this book is the second half, which consists of selections from his philosophical writings. The author considers Ockham to be greater as a philosopher than as a social reformer, and therefore ignores his sociological output. Yet the reader is likely to be left with an insatiable curiosity to know something about his political and sociological writings, and to regret that selections from them were not included. All of which brings us back to the first statement in this review—that the covers of this book are too close together to do justice to the remarkable character whom it celebrates.

BIOLOGY AND MARXISM.
By Marcel Prenant. International Publishers, New York. $2.50. 8½ x 5½; xxiii + 223; 1938.

There is a school of thought which places Marxism in the category of religions and this view seems to be well grounded when it is noted how strong is the faith that the Marxists manifest towards the written words of the master and his principal apostles: Engels and Lenin. Such a faith pervades this work in which Prenant discusses the validity of dialectical materialism as the philosophical method of approach to the study of biology, and of human evolution in particular. The main thesis advanced by the author is that the "Marxist philosophy of dialectical materialism, being a sort of quintessence of the scientific method itself, is able to help the biologist both by pointing the way towards the kind of hypotheses

which it will be most profitable for him to form and by indicating which questions are meaningless and which are unanswerable." To prove his thesis the author first of all presents an excellent outline of the existing knowledge in biology. He discusses in a thorough and sound manner the cell, heredity, evolution, animal behavior and societies, population growth and kindred topics. He then proceeds to show how the modern discoveries and conclusions would have been quickly achieved if investigators had been guided by the writings of Marx, Engels, or even Lenin. Typical is his treatment of the problems of population growth. After citing the studies of Pearl, Gause, and Teissier he notes that Engels was already aware of the existence of "laws" of population growth because he had said: 'For that matter, the organisms of nature also have their laws of population, which have been left almost entirely uninvestigated, although their formulation would be of decisive importance for the theory of the evolution of species'. Prenant omits to say that many others, even though not followers of Marx, had already expressed the same or similar thought. In a way, the efforts of Prenant remind one of the literary game in which references to automobiles and other modern inventions are sought in the plays of Shakespeare. But the author is grimly serious, and his conclusion in essence is that the modern developments in biology have demonstrated the correctness of Marx's views, and that therefore the future will also show that the classless society visualized by Marx is the end result of the evolution of man. There is a very laudatory foreword by Joseph Needham who, however, seems to have arrived at an interpretation of dialectical materialism different from that of Prenant, thus increasing the reader's confusion.

THE LIFE OF CHEVALIER JACKSON. *An Autobiography.*
By Chevalier Jackson. The Macmillan Company, New York. $3.50. 8⅜ x 5½; x + 229 + 64 plates; 1938.

The story of his childhood and early adolescence is here given in far more interesting detail than are the well-known scientific adventures of this famous doctor. However, his early struggles against poverty, a frail physique and great sensitivity, climaxed by serious illness in later life, only help us to appreciate the magnitude of his achievements. He writes at length of the agony of his days at school where he bore in stoical silence the teasing and physical brutality of his larger classmates, but of his years in Jefferson Medical College he speaks only briefly, preferring to enlarge on his hardships and starvation diet during that time rather than upon his professors and their teachings.

Influenced by the writings of Sir Morell Mackenzie to study laryngology, he sailed (steerage) to England to visit the Mackenzie clinic, giving a full account of his crossing and poor rations while in London, but neglecting to mention again either Mackenzie or his clinic. At the early age of 35 Dr. Jackson was elected to the chair of laryngology at Western Pennsylvania Medical College and later professorships were created for him in many leading universities, but throughout the rest of the book as in the earlier part the account of his professional activities is not given in as much detail as those interested in the work rather than the character of the man might wish. He prefers to emphasize his abhorrence for tobacco and alcohol, the amazing extent of his charity work, and his idealistic aims in training assistants and spreading his knowledge.

The volume is lavishly illustrated with sketches by the author who is artistically as well as scientifically inclined. An index and a group of photographs both personal and professional supplement the text.

THE NEXT BRITISH EMPIRE. *A Population Policy for Home Amenity and Empire Defence. By R. A. Piddington. John Murray, London.* 6s. net. 7¼ x 5; xi + 294; 1938.

Any sensible person, even though English, can see that the outlook for the future of the British Empire is not very bright. Various not very successful attempts have

been made to stir the powers that be into doing something about saving Great Britain from the decline they believe is imminent. This book has just such a purpose. The author sees the signs of an early collapse in the falling English birth-rate which is the effect, he notes, of urbanism and excessive population density in general. After depicting in very dark colors how Great Britain will become the prey of other and more virile countries if the present trend is allowed to continue unchecked, the author presents as his remedy a plan of action that is at least drastic and exciting. He proposes to move the people of the British Isles lock, stock, and barrel to Canada and establish there the center of the Empire which would contain only Canada, Australia, New Zealand, South Africa, and the geographic features of what are now the British Isles. He considers giving India back to the Indians; much of Africa to Germany (or anybody who wants it); ditto for Gibraltar, Malta, etc. In this way most of the have-not countries would be appeased, Australia and Canada would be protected, and the British Empire would survive in a more compact form. In addition, by careful planning, the present ills—unemployment, dole and over-industrialization—could be avoided and the Empire would flourish again and everybody would live more happily. The author's earnestness is impressive and the brilliantly written book makes interesting reading. The clear and cogent analysis of the principal factors associated with the declining birth-rate is masterly. Altogether this is a remarkable book, even though its suggested solution does not seem at the moment altogether probable as realistically practicable.

GROUP ADJUSTMENT. *A Study in Experimental Sociology.*

By Wilber I. Newstetter, Marc J. Feldstein and Theodore M. Newcomb. School of Applied Social Sciences, Western Reserve University, Cleveland, Ohio. $2.00. 9 x 5¾; xv + 154; 1938.

Experimental sociology is one of the developments resulting from the realization that notwithstanding all the tomes on sociology our knowledge about social behavior is practically nil. Utilizing various ways and means, scattered small groups of investigators are now attempting to develop and apply observational techniques to the study of group behavior. The Wawokiye Camp research project about which an account is given in this volume represents one of these. In essence, the methods used here have already been employed by child psychologists and consist in observing and measuring the attitude and behavior of adolescents in their contacts with one another. A technique of measuring and scoring the individual behavior has been developed and is described here, but from the account given a judgment on its adequacy cannot be reached. One of the principal conclusions drawn from this investigation is that the group status of the individual is highly correlated with the cordiality manifest by the group towards the individual but is found to have a low correlation with the attitude of the individual towards the group.

It must be noted in passing that the correlation coefficient has been employed here with the same familiarity and nonchalance one usually finds in statistical investigations by students of psychology and education; a fact which always chills the blood of the biostatistician who is only too aware of the pitfalls connected with that valuable statistical constant.

However, this is pioneer work and deserves to be encouraged; moreover any attempt to evaluate either methods or results at this stage would certainly be premature.

CLIMATE AND ACCLIMATIZATION. *Some Notes and Observations.*

By Sir Aldo Castellani. John Bale, Sons and Curnow, Ltd., London. 10s. 7¼ x 4¾; ix + 198; 1938.

Professor Castellani repeatedly states that this discussion regarding the effects on man of variations in climatic conditions must be regarded simply as a collection of notes. Nevertheless, it turns out to be an adequate summary of the subject particu-

larly valuable because the comments are dictated by the author's long experience and unusual competence. Following an introductory chapter on climatology, the remainder of the book is a critical survey of the facts about the changes in bodily functions and in disease susceptibility produced by changes in temperature, pressure, winds and other atmospheric conditions with special reference to the effects noted on the white man in the tropics. In addition, the writer outlines the measures which he considers most useful to aid the acclimatization of the white man in tropical and sub-tropical regions. For some time Castellani has maintained that the alleged deleterious action of the tropical climate on the white man has been greatly exaggerated, although some effects on the endocrine system and in the psychic sphere are to be noted. The majority of diseases which affect the Europeans in the tropics can be prevented, he believes, and in proof presents the really splendid results he obtained as chief of the Italian Medical Corps during the Ethiopian invasion. Judged by past experience, it would seem almost incredible that among one-half million troops in the field not one death was reported from dysentery and not one case of typhus, beri-beri, cholera, or gas gangrene; and that in total the morbidity and mortality (from disease) of the troops in Ethiopia was less than the experience of the army at home. These results must be a source of satisfaction to the author and are the most striking indications of the great progress that has been achieved in hygiene and sanitation.

AFRICA'S GOD. *IX—South Africa. Anthropological Series of the Boston College Graduate School, Vol. III, No. 2.*

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. $1.00. 9¾ x 6½; 54; 1938 (paper).

In Part IX of his study on the religion of Africa, Williams presents the replies from South Africa's missionaries, government officials, and educated natives to his questionnaires on tribal religions.

Despite the presence of a maze of tribal superstitions involving propitious and malignant spirits, ill-remembered oral traditions concerning former tribal beliefs and modes of worship, ancestor-cults, and decadent and vestigial religious practices, the collected evidence points to the fact that monotheism is, or has been, practiced in the tribes of South Africa. The question of past Hebraic contacts with South African tribes is interestingly discussed, and the many similarities between Pentateuchal Laws and the tribal customs are noted, especially those of circumcision, the levirate, purification of women after child birth, cleaning rites after burial, and peace-offerings. There are pointed out in the material on the Zulus as many as thirty parallels to Jewish customs, and on the Basutos twenty-five customs suggesting Jewish origin.

Possible etymological origins of the different names by which the Supreme Being is called in the many tribes, interesting historical data about the tribes, especially that concerning Chaka, the former Napoleon of South Africa, and divers other odd bits of information concerning South African tribes by persons well acquainted with all their peculiarities are included in this pamphlet. In addition, there is an article by J. W. Murphy, *S. J.* on the excavation of ceramic fragments at Teleilat Ghassul in the southern section of the Jordon Valley.

HISTORICAL AND ETHNOGRAPHICAL MATERIAL ON THE JIVARO INDIANS. *Smithsonian Institution, Bureau of American Ethnology, Bulletin 117.*

By M. W. Stirling. U. S. Government Printing Office, Washington, D. C. 35 cents. 9⅛ x 5¾; xi + 148 + 37 plates + 1 folding map; 1938 (paper).

Translations of many historical accounts of the Jivaro Indians (habitat: eastern Ecuador) largely make up the first half of this bulletin. From the sixteenth century these tribes have had contact and conflict with soldiers, missionaries, gold seekers, and commercial fortune hunters. Yet their method of living and the nature of the land has made them indomitable.

The story of the present day Jivaro is one of much interest. Stirling tells of the

warlike manner of the Indians, with detailed accounts of their taxidermic art in preparing heads. Primitive traditions abound in the otherwise simple domestic life of these people, but as in many primitive cultures, some of the customs and superstitions may have a sound physical basis. For one learns that when treating a patient the witch-doctor sucks the afflicted part and spits out the evil spirit. Some illnesses are not due to these disease spirits.

> Colds, fever, dysentery, and others are regarded as natural sicknesses in which no spirit is involved. The Jivaros are very much afraid of contagious diseases. Whenever a man develops a cough or symptoms of some contagion the other Indians abandon the house and disappear into the bush, where they will have no contact with him. In the same way, they will avoid all persons who have been in contact with the sick person after he contracted his illness.

Many good photographs depict the Jivaro way of life, and the bulletin is well indexed.

POLITICAL ARITHMETIC. *A Symposium of Population Studies.*

Edited by Lancelot Hogben. Macmillan Company, New York. $9.00. 9¼ x 6; 531; 1938.

A collection of twelve papers by various members of the department of social biology of the University of London are presented in this volume together with two articles in the form of introductions written by the editor, Professor Hogben. In the first part of the book are included papers respectively by Kuczynski, Charles, and Glass, all dealing with certain aspects of human fertility. In part two, Gray, Moshinsky, Charles, Glass and Morgan are represented by papers on the general subject of education, income, and ability. An article on blood groups and race by Davis has been for some obscure reason included in this section. On the whole, these essays are all of a high standard and furnish additional information about studies already reported by the several authors. The main point of interest of this book is the introduction: Prolegomena to Political Arithmetic, by Hogben. In it he begins by recalling the great contributions of William Petty to British demography and proceeds to discuss the subject of research in social sciences. He emphasizes, in particular, the need for more facts and for measures which will allow the practical utilization of the knowledge thus gained. All will agree in theory, at least, with the ideas expressed by Hogben although it is not quite clear why they should be couched in the bellicose terms he uses and why he should feel so strongly against Malthus and the so-called Austrian school of economists.

KAZAK SOCIAL STRUCTURE. *Yale University Publications in Anthropology Number 20.*

By Alfred E. Hudson. Yale University Press, New Haven; Oxford University Press, London. $1.50. 9¾ x 7; 109; 1938 (paper).

This brief monograph dealing with "certain features of Turco-Mongol social structure by an examination of some of the processes . . . in their development" is well put together. From field work and a study of the literature, the author has uncovered the story of a now sedentary people, the Kazaks, who once were nomadic stock-breeders, and who are descended from the invading armies of Chingis Khan in the 13th century. They inhabit the steppe country east of the Caspian Sea as far as the Altai Mountains. The customary tribal formation was occasionally altered when an enterprising son of some important family would strike out for himself with his herds and his dependents, such seceding groups coming to be considered as separate and independent tribes; at various times such small tribes became reunited under a strong leader. It was not until the 16th century, however, that a Kazak "nation" appeared. In the 17th and 18th centuries the Russians conquered them, and Kazakstan is now an autonomous republic within the Soviet Union.

The author concludes with a short discussion on the development of Mongol social structure, and its probable relation to Kazak culture.

DEATH ON THE INSTALLMENT PLAN.

By Louis-Ferdinand Céline. Translated from the French by John H. P. Marks. Little, Brown and Co., Boston. $2.75. 8¼ x 5½; 593; 1938.

Unless we are greatly in error this is an important book that will last. Because of the obscenity and filth with which its first half or so is heavily loaded, by evidently deliberate intent of its author to shock, it is a somewhat unpleasant and repulsive book. But dirty words are really in no wise essential to the author's basic purpose, which is to set forth a scientifically accurate account of the development of a human personality from childhood to adulthood, and the important circumstances of the environment, physical and biological, in which that development took place and by which it was influenced. The result is a great contribution to human biology as well as to literature. When one has read this book, and the Pasquier Chronicle—also written by a physician—one knows things about the French people that will never be forgotten and that no textbook of anthropology, ethnology, psychology, or biology has ever taught or is ever likely to. We strongly recommend this work to our readers, but couple with the recommendation the suggestion that they start their reading with Chapter II. Chapter I is only confusing and irritating, and has no significant relation to anything that follows in the book.

THE PEYOTE CULT. *Yale University Publications in Anthropology Number 19.*

By Weston La Barre. Yale University Press, New Haven; Oxford University Press, London. $2.50. 9¾ x 7; 188 + 2 plates; 1938 (paper).

This is a comparative and integrated treatment of the many studies that have been done on the peyote cult in individual tribes. The first chapters discuss the botanical and physiological aspects of peyote, a small cactus growing in the Rio Grand Valley and southward, whose salient characteristic is its production of visual hallucinations as well as kinaesthetic, olfactory, and auditory derangement. The study covers the ethnology of peyotism, and the use of peyote in religious rituals in various tribes in Mexico and, since about 1870, in the United States, particularly in the plains region where nearly all groups now use it. The last chapters deal fully with the psychological aspects of peyotism and its historical interpretations.

These compact pages are supplemented by long and numerous foot-notes, a fourteen-page bibliography and 9 lengthy appendices.

THE AGRICULTURAL AND HUNTING METHODS OF THE NAVAHO INDIANS. *Yale University Publications in Anthropology Number 18.*

By W. W. Hill. Yale University Press, New Haven; Oxford University Press, London. $2.50. 9¾ x 6¾; 194 + 4 plates; 1938 (paper).

Among the Navaho Indians, hunting and agriculture were and still are the principal means of making a living. Intimately associated with both activities a complicated system of rituals and taboos has been developed. With a wealth of detail, the author describes the rites as well as the rationalizations and the technological characteristics with which they are associated. From his account it appears that the ceremonial and the practical aspects of the economic behavior are so well integrated that one aspect has become the necessary complement of the other. Moreover, it is seen that this adjustment has not been altered by the changes that the contact with the whites has produced in the technique of hunting and cultivating. The author has presented his observations in a straightforward and interesting manner and by this investigation has contributed to the little knowledge there is of the practical behavior of primitive peoples. There is an adequate bibliography.

AN EXPERIMENT IN THE REGISTRATION OF VITAL STATISTICS IN CHINA.

By C. M. Chiao, Warren S. Thompson and D. T. Chen. Scripps Foundation for Research in Population Problems, Oxford, Ohio. $1.00. 8⅞ x 6⅞; [6] + 115; 1938 (paper).

As all students of population are well aware, the largest unknown quantity in the world's population is that of China. In 1930–31 Dr. Thompson, representing the Scripps Foundation, visited the University of Nanking, where he arranged with Dr. Chiao and Dr. Chen, of the University's Department of Agricultural Economics, for an actual registration of the vital statistics of a Chinese community of some 20,000 people. This jointly sponsored experiment was carried out in Hsiao Chi, a presumably typical area in the lower Yangtze delta. Detailed analyses of the data from this registration and from a census carried out in 1932 are now presented, relevant to nuptiality, natality, mortality, migration, and natural increase.

In an appendix on "The Outlook for the Improvement of Standards of Living in China," Thompson discusses the probability that the benefits of any agricultural and industrial progress will largely go to the support of more people, rather than to the improvement of living-standards in China.

FINLAND IN SUMMER.

By F. J. North. W. Heffer and Sons, Cambridge. 10s. 6d. net. 8½ x 5½; xv + 233 + 76 plates; 1938.

This is a rather dull book, but like many other dull books it is full of desirable information about a country that is being increasingly visited by the foreigner. If the book is dull the Finnish people certainly are not, so we can promise the reader that *Finland in Summer* will give him an excellent background for a delightful visit to a country that is new as a state but old as a nation; where the people—young, middle-aged, and old—still cling to the habit of being industrious; where the trend in production is along modern lines yet a strong sense of the value of the arts and crafts as well as the traditions of long ago is maintained; where wood, in spite of the vast quantities of it that have been consumed in the production of foreign newspapers, is still abundant enough to be used by the railroads as fuel.

The volume is well illustrated and indexed and contains a useful bibliography.

OTHER MEN'S LIVES.

By Sir George Dunbar. Nicholson and Watson, Ltd., London. 10s. 6d. net. 8¼ x 5½; xi + 355; 1938.

Dunbar has attempted to furnish a panoramic view of the actual mode of living of primitive man. He begins by reconstructing from the relics uncovered a detailed picture of the daily life of prehistoric man, his food, shelter, art, and means of earning a living. From prehistoric man he passes to a survey of primitive peoples and summarizes some of the available information regarding Tasmanians and North American Indians. He concludes with a detailed report of his own observations on the Tibetan border tribes that have remained untouched by the civilizations of either Tibet or Assam. The whole book is well written, but this last section is the most interesting since it contains observations about peoples not generally discussed in anthropological literature. Technically a competent piece of work and well worth reading.

L'HYGIÈNE SOCIALE DES VILLES. I. L'URBANISME ET LE TRAVAIL SOCIAL. *Bibliothèque de l'Institut d'Urbanisme de l'Université de Paris.*

By R. H. Hazemann. Vincent, Fréal et Cie, Paris. 9⅝ x 6¼; 22; 1937 (paper).

It is generally accepted today that the problems of public health and economic welfare are closely intertwined. Hazemann, therefore, proposes the creation of health centers in every community, particularly the urban ones, in order to coordinate the efforts at disease control and social assistance. In this pamphlet a plan for such centers is presented together with an outline of the type of personnel desired and an estimate of the cost. In the main, the organization proposed does not differ materially either in scope or function from that evolved in hospital dispensaries and health districts of some of the large cities of this country. The principal exception is that the author expects the state to provide all the funds for such enterprises, because in his opinion the cost would always be much less than the present financial loss to the country caused by disease and illness.

THE NATURAL HISTORY OF POPULATION. *University of London Heath Clark Lectures 1937.*

By Raymond Pearl. Oxford University Press, London. 10s. 6d. *Oxford University Press, New York,* $3.50. 8½ x 5¼; xii + 416; 1938.

This book embodies the Heath Clark Lectures of 1937, together with much additional material relating to human fertility and factors that influence it. Some indication of the scope of the book is given by the chapter heads: Biological background; the biology of fertility; human and animal reproductive patterns; the extent of contraceptive efforts in the American population; the effects upon natural fertility of contraceptive efforts; world population, past, present, and future. Following the text are successively a section of notes; an appendix of statistical tables; an appendix describing methods by which the author's original data were collected; a bibliography of over 700 titles; an index.

THE HEALING KNIFE. *A Surgeon's Destiny. By George Sava. Harcourt, Brace and Co., New York.* $2.50. 8 x 5½; x + 310; 1938.

The remarkable story of a young Russian who persevered until he attained his goal in life—to become a surgeon. From the time that he removed a bullet that was lodged dangerously on the pericardium of a fellow soldier (a pocket knife being his only surgical instrument) until he finally reached England's shores as an accredited surgeon, our hero worked in a morgue where he surreptitiously dissected cadavers during the night; earned his way through school working as a waiter; as a model; as a stoker; rode as a stowaway on a transcontinental train; and had two unfortunate romances. George Sava (a pseudonym) is indeed a fortunate person, for not only does he possess a surgeon's instinct, but he also enjoys psychic powers that stood him in good stead in times of stress. With these qualifications and experiences in addition to a rather pleasing literary style, the author has produced a readable book.

SHAMANISM IN WESTERN NORTH AMERICA. *A Study in Cultural Relationships.*

By Willard Z. Park. Northwestern University, Evanston and Chicago. $2.25. 9 x 6; viii + 166; 1938.

A comprehensive study of shamanism among our western Indians providing much that has been lacking in comparative studies of Indian culture. Much credit is due Dr. Park for his untiring efforts in the field, and for his keen judgment in evaluating and classifying his materials. It is found that the shamanistic rites play an important rôle in the lives of the Paviotso Indians, especially in curing the sick and in charming game. From the careful first-hand study of the distribution of customs and institutions of shamanistic practice, the author suggests that the Paviotsos have had relations with tribes over a much wider area than had originally been supposed.

The volume is well indexed and contains a valuable list of bibliographic references.

VIVID EXPERIENCES IN KOREA.

By Wm. H. Chisholm. Foreword by Howard A. Kelly. Bible Institute Colportage Ass'n, Chicago. $1.00. 7¼ x 5; 136; 1938.

In this little book, Dr. Chisholm has recounted a series of characteristic incidents in the life of a medical missionary at his work in a foreign land, and has intimated in each of these the widespread need for medical and spiritual aid. The purpose of the publication has obviously been that of bringing to the public mind the fact that foreign peoples are entirely capable of receiving the Christian message, and that the work of a foreign medical missionary is successful in some measure at least in its purpose of winning souls.

BIBLIOGRAPHY ON LAND UTILIZATION, 1918–36. *U. S. Department of Agriculture. Miscellaneous Publication No. 284.*

By Louise O. Bercaw, Annie M. Hannay and Mary G. Lacy. Government Printing Office, Washington. $1.50. 9¼ x 5⅞; iv + 1508; 1938 (paper).

This companion volume to the *Bibliography on Land Settlement*, issued in 1934 as *Miscellaneous Publication* 172 by the United States Department of Agriculture, contains selected references to the literature on the economic aspects of land utilization and land policy in the United States and in foreign countries, published for the most part during the period 1918–36. "Relatively few references to the early land policies of the United States and of the individual states have been included, mainly because a bibliography on this subject is in preparation by the Bureau of Agricultural Economics." There is an index of authors and of subjects.

AMERICA'S COOK BOOK.

Compiled by The Home Institute of The New York Herald Tribune. Charles Scribner's Sons, New York and London. $2.50. $8\frac{1}{4}$ x $5\frac{1}{2}$; xvi + 1006; 1938.

This is indeed a remarkable book. Its 1006 pages contain (besides something over 3000 recipes) practically everything one wishes to know about the buying and preparation of food, menu making (128 menus), table setting and serving, the herb garden, foreign recipes to the number of 138, etc. etc. Furthermore, it is so constructed that the recipe section stays open—one need not weight the pages. We had a somewhat superior feeling when two of our favorite American recipes could not be found herein.

THE ADOLESCENT PERIOD. *A Graphic and Pictorial Atlas. Monographs of the Society for Research in Child Development. Volume III, Number 3. Serial No. 16.*

By Frank K. Shuttleworth. Society for Research in Child Development, National Research Council, Washington. $1.00. 9 x 6; v + 246; 1938 (paper).

Contained in this volume are 440 graphs and 18 series of photographs touching on the diverse aspects of adolescent development. They depict the quantitative information collected by American investigators, particularly on the physical growth, health, physiology, behavior, intelligence, and economic and social status of adolescents. Obviously any such enterprise as this can never achieve completeness, but the author deserves much credit for a compilation which will be found very useful for purposes of reference.

COMING INTO BEING AMONG THE AUSTRALIAN ABORIGINES. *A Study of the Procreative Beliefs of the Native Tribes of Australia.*

By M. F. Ashley-Montagu. Foreword by B. Malinowski. E. P. Dutton and Co., New York. $5.00. $9\frac{3}{4}$ x 6; xxxv + 362; 1938.

The American edition of a treatise already noted (Q. R. B., 13: p. 248) in these pages.

INFANT CARE. *U. S. Department of Labor, Children's Bureau. Publication No. 8.*

Government Printing Office, Washington. 10 cents. $9\frac{1}{4}$ x $5\frac{3}{4}$; iv + 107; 1938 (paper).

ZOÖLOGY

THE SPRAT AND THE SPRAT FISHERY OF ENGLAND. *Ministry of Agriculture and Fisheries. Fishery Investigations, Series II. Vol. XVI. No. 2.*

By J. Armitage Robertson. H. M. Stationery Office, London. $1.40. $10\frac{1}{2}$ x $7\frac{1}{4}$; 100; 1938 (paper).

THE ENGLISH PLAICE-MARKING EXPERIMENTS 1929–1932. *Fishery Investigations, Series II, Volume 16, Number 1.*

By C. F. Hickling. H. M. Stationery Office, London. 4s. (*Obtainable in North America from British Library of Information, New York.*) $1.25. $10\frac{3}{4}$ x 7; 84; 1938 (paper).

The English sprat fishery depends upon a coastwise immigration of shoals in winter, undertaken by adult fish in the early stages of sexual maturation. In the first publication here noticed, material—much of it illustrated with tabular data—is presented on the geographical distribution, specific characteristics, early life-history and development, age- and size-composition in adult shoals and in the

samples taken, sex-ratio, maturity and ripening of the gonads, stomach contents, fat yield, parasites and disease of the fish, and the economic and commercial status of the sprat-fishing industry.

The plaice marked in the experiments described in the second publication were liberated along the continental coasts from Horns Reef to the Haaks, in each of the years from 1929 to 1932. Most of the fish were recaptured near the position of liberation as late as in the third year after release. However, they did distribute themselves widely, the most rapid dispersion appearing to be in the late spring or summer. In a few cases where a significant difference between the sexes was found in the area of dispersion, the males were found more widely dispersed than the females. Likewise, larger fish dispersed themselves more widely than the smaller, and the older fish more widely than the younger. Of the plaice marked in any given experiment, those which wandered away from the coasts grew substantially more than those which were captured near the coasts. Growth rates of fish marked at the different stations, and at different seasons of the year, are noted.

THE MAMMALS OF CHINA AND MONGOLIA. *Natural History of Central Asia, Vol. XI, Part 1.*

By Glover M. Allen. Central Asiatic Expeditions, American Museum of Natural History, New York. $10.00. 11 x 8¼; xxv + 620 + 9 plates; 1938.

This report on the mammals of China and Mongolia is the fifth of a series of twelve volumes to appear on the biology and geology of Central Asia. The material is based on collections made during the American Museum's First and Second Asiatic Expeditions and the Central Asiatic Expeditions of 1921–1930.

All mammals (except the typical rodents, an account of which will appear in Part II) known or believed to occur in this area are described together with notes on their occurrence and habits. Keys to the genera and species, distribution maps, photographs, and a bibliography of 40 pages form part of this report. The bibliography, incidentally, is for both Part I and II; the latter volume will include the index.

The similarity of the biota of northern North America and northern Asia is well known to zoogeographers, but south of the transcontinental evergreen forest belt this similarity is lost. "The obvious conclusion is that the former (northern latitudes) group owes its similarity to a more recent continuity of land area, while the latter group (southern latitudes) has been separated for a far longer period, allowing time for evolutionary changes in some types and the extinction or increase in others, with a resulting lack of similarity at the present time."

This monograph is of the first rank of quality and significance and together with the second part will form a lasting record for a region where such studies are not easily undertaken.

AFTER BIG GAME IN THE UPPER YUKON. *By Nevill A. D. Armstrong. John Long, London.* 18s. net. 9 x 6; 287 + 16 plates; 1938.

In a previous book Major Armstrong related the most important and exciting adventures of his thirty-odd years in the Yukon. In this he describes in greater detail the hunting trips that he led in the upper Yukon region in 1914, 1925, 1926. They are the records of a genuine sportsman and an acute observer who can, moreover, make the reader enjoy the thrills and natural beauties he perceived and here depicts in vivid language. On one of these expeditions a new species of caribou was discovered and in this narration he includes notes on the habitat and life of this and other species of animals as well as antler measurements and a number of interesting photographs. An estimate of the cost of this type of expedition and advice on trapping methods are also given. After reading Major Armstrong's story it must be confessed that it is difficult to resist the invitation to visit this land which he considers the finest sporting country of its kind left on earth, a land of immense wilds with a glorious climate and abundant with game, birds and fish.

INSECTS OF CITRUS AND OTHER SUBTROPICAL FRUITS.

By Henry J. Quayle. Comstock Publishing Co., Ithaca, N. Y. $5.00. 9 x 6; ix + 583; 1938.

This book will be of interest to all entomologists and horticulturists but especially to those having to do with the pests of citrus and other subtropical fruits. The author, long a student of these problems, has produced an authoritative work. Besides the citrus fruits, attention has been paid to insects attacking the avocado and other subtropical fruits such as the *Vinifera* grape, Persian walnut, almond, pecan, fig, olive, oriental persimmon, and pomegranate. The biology and economics of pest insects, their parasites, and predators have been fully treated. Much practical and specific advice is given to growers and their advisors, and the excellent bibliographies furnish useful references for entomologists, horticulturists, and ecologists. The numerous and excellent illustrations are a valuable addition to a work of this kind which concludes with a detailed index.

In reading this book we are once again impressed with the importance and need for "growth of population" studies on introduced organisms—whether it be bacteria, insects or men—or on organisms which have flourished, have died out and again have flourished in a particular locality.

THE SOCIAL LIFE OF ANIMALS.

By W. C. Allee. W. W. Norton and Co., New York. $3.00. 8 x 5½; 293; 1938.

The account which Professor Allee gives here of some aspects of animal social behavior represents a semi-popular summary of the work done by himself and associates as well as by other students of the subject, presented as a series of Norman Wait Harris lectures at Northwestern University. Two fields of experimental work with which his name is particularly linked present the main topics for discussion; the effect of population size on the survival and growth of populations and individuals under specified conditions, and group organization and behavior. The author describes the experimental procedures and results very clearly and in sufficient detail, and has succeeded in making the book an interesting as well as valuable contribution to the literature. The two final chapters on "Human implications" and "Social transitions" aim to correlate and integrate the animal observations and experiments with the problems of human sociality.

An important book, that will enhance its author's already high reputation in the field.

POULTRY HUSBANDRY. *Second Edition.*

By Morley A. Jull. McGraw-Hill Book Co., New York. $4.00. 9¼ x 6; vii + 548; 1938.

Neither the serious poultry breeder nor the amateur can afford to be without this book. It covers the field with great thoroughness, beginning with the breeds of chickens, the biology, breeding principles and practice, and continues with incubation and rearing, housing, feeding, disease, etc. The latter part of the book has to do with egg- and poultry-marketing problems, and the economics of production and marketing. Any one who masters the chapters on the biology of the chicken and on breeding principles and practices (and these chapters are written with great clarity) will be well equipped to enter the field of poultry husbandry. The book contains numerous illustrations, many tables, reference lists at the end of each chapter, and an excellent working index.

ОСНОВЫ ЭКОЛОГИИ ЖИВОТНЫХ.

Д. Н. Камкаров. Государственное Издательство медицинской литературы. Ленинград. 9 руб.45 коп. 602 стр. 1938.

[FUNDAMENTALS OF ANIMAL ECOLOGY.

By D. N. Kashkarov. State publishing house for medical literature. Leningrad. 9 roubles 45 kop. 602 pp. 1938.]

This is perhaps the most thorough textbook of animal ecology so far written. The first edition of it entitled "*Communities and Environment*" was published in the Russian language five years ago. The

second edition now under review is enlarged by approximately three times the original volume. There are fourteen chapters dealing with such topics as the subject of ecology, environmental factors, life zones, ecology of domesticated animals, biocoenosis, adaptation of animals from an ecological viewpoint and some others. The whole book impressively shows that ecology is a living and rapidly developing science with many problems of first-rate importance.

ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIII, Part 2, Numbers 5–9.*

New York Zoological Society, Zoological Park, New York. $1.45. 10½ x 7; 99–217; 1937 (paper).

The larger part of this number is devoted to the eighth report on the planktonic contents of nets drawn at various levels off the coast of Bermuda on the Bermuda Oceanographic Expeditions. This paper, by H. B. Bigelow, is on "Medusae taken during the years 1929 and 1930." No new species are reported, but information on the morphology of several has been extended and much has been gained from the distributional standpoint. There are included in the report 23 text figures, many tables giving data on morphological records and on distribution (horizontal and vertical), and a bibliography of 130 titles.

Other papers in the number deal with Classification of carp-like fishes; Tissue responses of *Cyprinodon variegatus* to the Myxosporidian parasite, *Myxobolus lintoni*; Electrical characteristics of the electric tissue of the electric eel, *Electrophorus electricus* (Linnaeus); and Colonial rattlesnake lore.

LES ARAIGNÉES.

By Lucien Berland. Delamain et Boutelleau, Paris. 15 francs. 7¼ x 4¾; xii + 175; 1938 (paper).

When it comes to writing books on nature, the French are incomparable masters. They seem to possess the knack of presenting facts in such a pleasant and unpedantic manner that the reader forgets that he is not reading a novel and becomes absorbed in the unfolding drama of the natural world. Whether it is the French mind or the language which produces this effect, we don't profess to guess. In either case here we have the story of spiders, not only what they are and where they live, but also how they spend their lives, what they eat, and many other phases of their natural history as told by an authority on the subject in a most informal and delightful manner.

LITTLE LIVES. *The Story of the World of Insects.*

By Julie C. Kenly. Illustrated by Edna Reindel. D. Appleton-Century Co., New York and London. $2.50. 8 x 5¼; xviii + 271; 1938.

"There is a whimsical likeness between the lives of insects and the lives of men. They face many similar problems in a similar manner; and it is this angle of the matter I have chosen to stress in the following pages, for to personalize the little creatures is to bring them into clearer focus, while to see them on their own special plane is to change them on the instant into literary material."

One might become skeptical of the results, but the author has succeeded in separating fact from fancy and has consequently produced an engaging series of stories on various insects and spiders for those uninitiated in insect lore.

ANIMALS OF THE SEASHORE.

By Horace G. Richards. Bruce Humphries, Inc., Boston. $3.00. 8 x 5⅓; 15 + 273; 1938.

To those who go to the shore only to bathe, to keep cool, and to fulfill social obligations this book will make no appeal. It is a strictly scientific work, couched in language that is simple without being childish, and illustrated by drawings and photographs culled from the publications of the leading scientific institutions of the east coast. With the help of this book the interested amateur can identify all the invertebrates he is likely to encounter at the Atlantic beach resorts. It will be especially appreciated

by beginners. The seven page index includes all scientific as well as popular names used in the text.

BIRDS AND MAMMALS OF MOUNT MCKINLEY NATIONAL PARK, ALASKA. *Fauna of the National Parks of the United States, Fauna Series No. 3.*

By Joseph S. Dixon. U. S. Government Printing Office, Washington, D. C. 35 cents. 9½ x 5¾; xii + 236; 1938 (paper).

This is another of a series of faunal reports on the National Parks of the United States. An account of each species of bird and mammal is given in four parts bearing the following headings: general appearance, identification, distribution, and habits. Many interesting histories are found in this volume, especially those on the larger mammals with which this park is so fortunately favored. Photographs of the animals and of the park itself enhance the volume and give an indication of the beauty of these national resorts.

THE REPTILES OF OHIO.

By Roger Conant. The University Press, Notre Dame, Ind. $2.00. 9 x 6; 200; 1938.

The author has been very careful to eliminate records of reptiles found in Ohio that in any way appear doubtful or obviously accidental. For this reason the list has been pared to thirty-nine species. Each of the species has detailed accounts of its occurrence in the state, its measurements and coloration, and notes on field observations made by the author. There are several plates of photographs and drawings, a bibliography, an index, and a glossary.

PARASITOLOGY. *With Special Reference to Man and Domesticated Animals.* [*This book is a general revision of Animal Parasitology.*]

By Robert Hegner, Francis M. Root, Donald L. Augustine and Clay G. Huff. D. Appleton-Century Co., New York and London. $7.00. 8¾ x 6; xxi + 812; 1938.

In this revised edition (first edition noticed in Q. R. B., Vol. 4, No. 4) the title has been changed to Parasitology for the reason that the title Animal Parasitology "appeared to be misleading, giving the impression that the parasites of man are not included." Owing to the death of Dr. Root, the section on medical entomology was revised by Dr. Huff, a former student of Dr. Root. The volume has, in every way, been brought up to date and many new figures have been added.

HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 473. Abt. IX, Methoden der Erforschung der Leistungen des tierischen Organismus, Teil 7, Heft 5 (Schluss). Methoden der Tierhaltung und Tierzüchtung (Ergänzung zu Abt. IX, Teil 1).* Containing following articles: *Die Züchtung und Haltung von Säugetieren,* by Friedrich Kröning; *Das Halten und Züchten von Schlangen,* by Carl Stemmler-Morath; *Das Halten von Affen und Menschenaffen,* by Carl Stemmler-Morath; *Methoden und Ziel der Nachweisung der Ektoparasiten und Überträger von Invasionen und Infektionen der Haustiere,* by E. N. Pawlowsky.

Urban und Schwarzenberg, Berlin. RM. 15 (25 percent reduction in countries outside of Germany). 10 x 7; 224 + xx; 1938 (paper).

The first three papers contained in this *Lieferung* deal with the husbandry and breeding in the laboratory of small experimental mammals (rabbits, guinea-pigs, rats and mice), snakes, and monkeys and anthropoid apes. The last paper treats methods of collecting and identification of fleas, ticks, and other ectoparasites of domestic animals, together with some material on their life cycles and relation to the spread of infectious diseases.

CHARACTER IN FISH.

By Clifford Bower-Shore. Epworth Press, London. 1s. 6d. net. 6½ x 4¼; 63; 1938.

This tiny book, written by a sentimental lover and observer of fish, declares that

fish possess individuality and character and are capable of displaying emotion and intelligence above that which is instinctive. The author ends with a plea that those who endow dogs and cats with such "nauseating, sentimental regard" will look upon fish with a little more "understanding, sympathy and appreciation".

TURTLES OF THE CHICAGO AREA. *Zoology Leaflet 14.*

By Karl P. Schmidt. Field Museum of Natural History, Chicago. 25 cents. 8½ x 5½; 23 + 2 plates; 1938 (paper).

This leaflet is ideal for a quick identification of the turtles in the vicinity of Chicago. There is a key to the ten species as well as colored plates of the heads and black and white figures of the plastrons of each. Every naturalist who isn't sure of his turtles should have this pamphlet near at hand.

GENERAL ZOOLOGY. *Third Edition.*

By H. L. Wieman. McGraw-Hill Book Co., New York. $3.50. 9¼ x 6; ix + 497; 1938.

The present edition has been almost entirely rewritten. Emphasis is put on the frog, especially in the early chapters of the book "with the idea of correlating the subject matter of the text more closely with that of the laboratory program."

CHARACTERISTICS AND CLASSIFICATION OF ANIMALS.

By E. Meiche and Marie Barrett. General Biological Supply House, Chicago; Denoyer-Geffert Company, Chicago; E. Meiche, 115 Camp Street, San Antonio, Texas. 50 cents. 23 x 17; 1 folding chart; 1938 (paper).

A small chart (17 x 23 inches) showing in condensed form the relationships, classification and chief characteristics of animals. It is designed to be used with any textbook, and should be helpful to teachers in beginning courses of zoology.

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY, *Vol. 41, No. 27. A New Trematode Paramphistomum castori sp. nov., from Castor canadensis baileyi Nelson, from Mary's River, Nevada,* by Charles A. Kofoid and James T. Park.

University of California Press, Berkeley. 25 cents. 10¼ x 6¾; 4; 1937 (paper).

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY, *Vol. 42, Nos. 3, 4, 5. The Pterylosis of the Falconiformes with Special Attention to the Taxonomic Position of the Osprey,* by Lawrence V. Compton; *Geographical Variation in Wood Rats of the Species Neotoma fuscipes,* by Emmet T. Hooper; *Territory, Annual Cycle, and Numbers in a Population of Wren-Tits (Chamaea fasciata),* by Mary M. Erickson.

University of California Press, Berkeley. No. 3, 50 cents; No. 4, 35 cents; No. 5, $1.25. 10¼ x 6¾; No. 3, 40; No. 4, 33; No. 5, 88; 1938 (paper).

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY, *Vol. 43, Nos. 1, 2, 3, 4, 6, 7, 8. The Devescovinid Flagellates Caduceia theobromae França, Pseudodevescovina ramosa new species, and Macrotrichomonas pulchra Grassi,* by Harold Kirby, Jr.; *The Life Cycle of Zygosoma globosum sp. nov., a Gregarine Parasite of Urechis caupo,* by Elmer R. Noble; *New Subgenera and Species of Diaptomid Copepods from the Inland Waters of California and Nevada,* by S. F. Light; *Brackish and Fresh-Water Nereidae from the Northeast Pacific, with the Description of a New Species from Central California,* by Olga Hartman; *Descriptions of New Species and New Generic Records of Polychaetous Annelids from California of the Families Glyceridae, Eunicidae, Stauronereidae, and Opheliidae,* by Olga Hartman; *Comparative Ecological Studies on the Terrestrial Isopod Crustacea of the San Francisco Bay Region,* by Milton A. Miller; *The Development of the External Form of the Rat, with Observations on the Origin of the Extraembryonic Coelom and Foetal Membranes,* by J. A. Long and Paul L. Burlingame.

University of California Press, Berkeley. No. 1, 50 cents; Nos. 2, 6 and 7, 35 cents each; Nos. 3 and 4, 25 cents each; No. 8, 65 cents. 10¼ x 6¾; No. 1, 40; No. 2, 26; No. 3, 12, No. 4, 4; No. 6, 20; No. 7, 30; No. 8, 42; 1938 (paper).

TRANSACTIONS OF THE SAN DIEGO SOCIETY OF NATURAL HISTORY, *Vol. 8, Nos. 33 and 34. New and Obscure Decapod Crustacea from the West American Coasts*, by Steve A. Glassell; *A Study of the Skull of the Pleistocene Stork, Ciconia maltha, Miller*, by Loye Miller.

Society of Natural History, San Diego, Calif. 10½ x 6⅞; No. 33, 44; No. 34, 4 + 1 plate; 1938 (paper).

BOTANY

SOILLESS GROWTH OF PLANTS. *Use of Nutrient Solutions, Water, Sand, Cinder, Etc. By Carleton Ellis and Miller W. Swaney. Reinhold Publishing Corporation, New York.* $2.75. 9 x 6; 155; 1938.

The difference between plant and animal alimentation consists chiefly in that while animals are dependent for their food supply on plants and other animals, plants in general have the ability to utilize the energy of sunlight in building up food stuffs from carbon dioxide from the atmosphere and certain inorganic mineral salts from the soil. The question naturally arises as to whether if a plant be supplied with adequate mineral substances in a readily assimilable form, it might not be able to dispense with the soil altogether, except as a means of physical support. For some years past the authors of this work have been experimenting in this direction. As experience accumulated they have succeeded in demonstrating to their own satisfaction at least, that the growth of plants in nutrient solutions is entirely practicable. The few instances where they have not succeeded may reasonably be attributed to the lack of suitable ingredients in the solution rather than the method *per se*.

The question that will come at once to the mind of every reader is, as these authors recognize, whether their experimental results imply that the farmer of the future will harvest his corn crop from a row boat. Such a contingency is by no means impossible but at the present time seems too remote to afford safe speculation. But greenhouse culture is a different thing. One of the big items in the expense of running a greenhouse is the renewal of the soil, which must be done at least once a year. By dispensing altogether with the soil a great saving may be effected, and wherever soilless culture in the greenhouse has been tried it has proved an economic success.

The book is brief but it is thorough and while the index covers only five pages it is adequate. The illustrations are from photographs taken by the authors.

A TEXTBOOK OF GENERAL BACTERIOLOGY. *Twelfth Edition, Revised. By Edwin O. Jordan. Revised by William Burrows. W. B. Saunders Company, Philadelphia and London.* $6.00. 9⅛ x 5⅝; 808; 1938.

AIDS TO BACTERIOLOGY. *Sixth Edition. By William Partridge. Revised by H. W. Scott-Wilson. William Wood and Co., Baltimore.* $1.50. 6¼ x 3⅞; vii + 300; 1938.

A TEXTBOOK OF BACTERIOLOGY. *Second Edition, Revised. By Thurman B. Rice. W. B. Saunders Company, Philadelphia and London.* $5.00. 9⅛ x 5¾; 563; 1938.

To Dr. Burrows, student and associate of the late Dr. Jordan, fell the task of revising the present edition of his textbook (*cf.* Q. R. B., Vol. 11, p. 106 for previous review) which, in the last thirty years, has gone through twelve editions. Perhaps the most extensive revision has been made in the chapter on virus diseases. The sections on oxygen supply and respiration, on filtration and isolation of bacteria in pure culture have been entirely rewritten, and many other changes and additions have been made, in line with recent developments of the subject.

Considerable revision has been made in the second of these texts especially in the sections concerning streptococci, the colityphoid groups, *Neisseria*, and the filtrable viruses; also in the sections dealing with standard methods of water and milk analyses and the standard method for performing the Rideal-Walker test. New sections deal with the bacteriology of swimming baths and the numerous new methods of laboratory diagnosis.

In the last revised text (first edition reviewed in Q. R. B., Vol. 11, p. 104) the

author has held to his original plan of presenting a relatively simple text of such size that the student can master it in one semester. Changes have been made only to bring the text up-to-date, to fill certain omissions or to correct inaccuracies and to improve or clarify certain passages.

HERBALS: *Their Origin and Evolution. A Chapter in the History of Botany 1470–1670. A New Edition Rewritten and Enlarged.*

By Agnes Arber. The University Press, Cambridge; The Macmillan Co., New York. $7.50. 9¼ x 6⅜; xxiv + 326 + 27 plates; 1938.

Mrs. Arber's delightful book on the evolution of the printed herbal first appeared in 1912 but has long since been unobtainable. It now reappears in new form, very much rewritten and enlarged.

A herbal has been defined as a book containing the names and descriptions of herbs, or of plants in general, with their properties and virtues. After the invention of printing, and during the years 1470 to 1670, there was much activity in the production of such works, and many old, and some very old, manuscripts were published along with numerous more recent studies. It is of this evolutionary period of the herbal, covering about two hundred years, that the author so entertainingly writes. Little attempt has been made to enter the field from the gardening or medicinal aspect, the subject being primarily treated from a botanical standpoint and secondarily from an artistic approach.

Since the first edition of this book appeared much new material has come to light and the author has taken full advantage of these researches. Much has been added concerning botany in Spain and Portugal and the origin of herbaria. The list of references has been greatly extended and is arranged in two appendices—(a) A chronological list of the principal herbals and related botanical works published between 1470 and 1670, and (b) An alphabetical list of the historical and critical works consulted during the preparation of this book. The illustrations showing portraits of the authors of the herbals and many of their plant drawings add greatly to the interest of the book. Excellent indexes are included.

PLANT HUNTER'S PARADISE.

By F. Kingdon Ward. The Macmillan Company, New York. $3.50. 7¾ x 5¼; 347; 1938.

The experiences of more than a year's exploration in northern Burma, Assam, and south-eastern Tibet have been carefully recorded by Mr. Ward in this interesting volume. Throughout the book the author has continuously emphasized the beauty and grandeur of the native flora, and has described in some detail the new species encountered. The journey was made for a two-fold purpose: (1) to discover, if possible, the source of the Irrawaddy river; and (2) to collect native flora and fauna. Ward and his partner Cranbrook were so interested in making their collections of flora and fauna, respectively, that the problem of the source of the Irrawaddy became of secondary importance and was dismissed with a guess and the statement that "the possibilities of its source are so limited that the problem is of academic interest only."

Mr. Ward's style of writing is so captivating that one finds it difficult to put the book down after once starting read it. The text is generously supplied with photographs depicting native scenery and inhabitants of the lands traversed. The book is concluded by appendices (1) The stages of the journey, distances, and method of transport; (2) Weather; (3) Zoology; and (4) Plants introduced from far northern Burma.

FOREST PATHOLOGY.

By John Shaw Boyce. McGraw-Hill Book Co., New York. $5.00. 9¼ x 6; ix + 600; 1938.

A well-planned and well-executed book. In a work of this type where space is limited but the subject an important one with many angles, the author is always plagued by numerous questions concerning what to include and what to exclude in the text in order to create a useful, up-to-date guide. Boyce, Professor of Forest Pathology at Yale, says in his preface:

> . . . conditions change, so that a disease which now seems important may in time be relegated to a minor position. On the other hand, with American chestnut approaching commecial extinction, justification for a detailed treatment of chestnut blight is

that the discussion becomes a historical record of the behavior of a virulent introduced parasite, a record which may be valuable in connection with the behavior of future introduced diseases.

The general scheme of the book can best be indicated by listing a few of the subjects discussed in the order in which they occur, following the introductory chapters on disease, fungi, and non-infectious diseases:—seedling diseases, root diseases, foliage diseases of hardwoods and of conifers, stem diseases (8 chapters), rots, etc. The volume is well illustrated and documented, contains a section on fungicides, a list of common names of plants used with scientific equivalents, and a detailed index.

MANUEL OF PTERIDOLOGY.

Edited by Fr. Verdoorn et al. Foreword by by F. O. Bower. Martinus Nijhoff, The Hague. Gld. 24. 9¾ x 6¼; xx + 640; 1938.

This manual, in its aims as well as in method of treatment, follows closely the same editor's well-known *Manual of Bryology*. It

is primarily, but by no means exclusively, designed for the taxonomist who is anxious to improve his methods and broaden his outlook. At the same time it offers to the general botanist working on the Pteridophytes the necessary fundamental facts about the group and a survey of the chief results of lines of investigation related to his own. . . . certain branches of the subject are dealt with more fully, because no good surveys of them have been published.

No attempt has been made to make this an exhaustive treatise. The twenty-three sections, each dealing with some special phase of the Pteridophytes, are rather a collecton of essays written by specialists. There are many illustrations throughout the volume, it is well documented and indexes of plant names and personal names are included. A valuable reference book.

DAS PHYTOPLANKTON DES SÜSSWASSERS. *Systematik und Biologie.*

By G. Huber-Pestalozzi. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. (In Germany) RM. 42 (paper); RM. 44 (cloth); (Outside of Germany) RM. 31.50 (paper); RM. 33 (cloth). 10 x 6¾; [6] + 342 + 66 plates; 1938.

After a general discussion of 125 pages of plankton invasion, types of phytoplankton, chemical considerations, theories of suspension, plankton parasites, preservation, etc., the author presents a systematized catalog, with descriptions, geographical distribution, specific distribution with regard to position in the water, and any other known biological information of the phytoplankton of lakes, ponds, swamps and other small fresh-water bodies throughout the world. Bacteria and fungi are included, the sections on these being provided with separate bibliographies. There are also author and subject indices for the separate parts. A valuable contribution by an authority in the field.

A COLLEGE TEXTBOOK OF PHARMACEUTICAL BOTANY. *Sixth Edition.*

By Heber W. Youngken. P. Blakiston's Son and Co., Philadelphia. $4.75. 9 x 6; xxviii + 793; 1938.

This revision, which includes changes in and reorganization of some of the chapters and the addition of 121 new figures, has been so made as to present a "broad general treatment of botany with particular stress upon those phases of this science such as histology, cell contents, taxonomy, and medicinal plants which are believed to be most helpful in preparing students to cope with botanical problems in pharmacognosy and in the practice of pharmacy."

PLANT PHYSIOLOGY. *Second Edition.*

By Nicolai A. Maximov. Edited by R. B. Harvey and A. E. Murneek. Translated from the Russian by Irene V. Krassovsky. McGraw-Hill Book Co., New York and London. $4.50. 9 x 6; xxii + 473; 1938.

This is a completely new book—the first edition (cf. Q. R. B., Vol. 6, No. 2) bore the title "Textbook of Plant Physiology"—bringing up to date the results of plant physiological research throughout the world. It is based on the translation of Dr. Maximov's fifth Russian text. The editors have introduced data and view-

points from recent American publications, revised the discussion, and amplified the presentation of the original author.

BOTANICAL STUDIES IN THE BLACK ROCK FOREST. *The Black Rock Forest Bulletin No. 7.*

By Hugh M. Raup. Black Rock Forest, Cornwall-on-the-Hudson, N. Y. $1.50. 9 x 6; vi + 161; 1938 (paper).

MORPHOLOGY

A TEXT-BOOK OF HISTOLOGY. *Functional Significance of Cells and Intercellular Substances. Second Edition, Thoroughly Revised.*

By E. V. Cowdry. Lea and Febiger, Philadelphia. $7.00. $10\frac{1}{4}$ x $6\frac{5}{8}$; 600; 1938.

A TEXTBOOK OF HISTOLOGY. *Third Edition, Completely Revised.*

By Alexander A. Maximow and William Bloom. W. B. Saunders Company, Philadelphia and London. $7.00. $9\frac{3}{4}$ x $6\frac{1}{4}$; xv + 668; 1938.

AIDS TO HISTOLOGY. *Fourth Edition.*

By Alexander Goodall. William Wood and Co., Baltimore. $1.25. $6\frac{1}{4}$ x 4; viii + 151; 1938.

In the preface to the second edition of Dr. Cowdry's excellent text (cf. review of first edition, Q. R. B., Vol. 10, No. 2) the author cheerfully lists the objections (contributed by his friends upon request) to the first edition and outlines the changes herein made. The introductory chapter is partly historical, no attempt being made to summarize histological details. "The whole book is an introduction to histology. Each and every system, and even their more important parts, are introduced individually immediately before the students become acquainted with them. Sometimes a few words suffice. Entire chapters are devoted to introducing the endocrines and the digestive system." We like the following statement: "The level of the presentation has not been lowered. To cater to the least informed members of the class is not our purpose." Many figures have been added including several which illustrate the histological changes in the process of ageing.

Previous reviews of the second of these texts have appeared in Vol. 6, p. 242, and Vol. 10, p. 110 of this journal. Professor Bloom has ably prepared the present edition of the late Dr. Maximow's book which has required considerable revision and many additions.

The fourth edition of Dr. Goodall's little book (in which the essential facts of histology are presented "in small compass as a guide to the junior student") has been revised and in part rewritten. New work on ossification, haematology, and the ductless glands has been incorporated.

AN INTRODUCTION TO VERTEBRATE ANATOMY.

By Harold M. Messer. The Macmillan Co., New York. $3.50. $8\frac{1}{2}$ x $5\frac{3}{4}$; xvi + 406; 1938.

MANUEL FOR COMPARATIVE ANATOMY.

By Leonard P. Sayles. The Macmillan Co., New York. $1.60. 10 x $7\frac{1}{2}$; xi + 214; 1938.

LABORATORY DIRECTIONS FOR COMPARATIVE VERTEBRATE ANATOMY.

By I. E. Gray. P. Blakiston's Son and Co., Philadelphia. $1.00. $9\frac{1}{4}$ x $6\frac{1}{4}$; x + 80; 1938.

The first text further swells a long list of mediocre vertebrate anatomy books. There is doubtful wisdom in writing such a book for a one semester course, involving the omission of material necessary to pre-professional students of biology. Thus fifteen pages are devoted to reproduction and early vertebrate development, one page to cranial nerves and one to the anatomic system. The volume contains a good glossary and index. Photographs of amphibians, reptiles and mammals show these forms well, but the drawings are generally poor.

Mr. Sayles' book contains several qualities looked for in a good laboratory manual. It gives detailed descriptions of the shark, pidgeon, and cat, bringing in other forms for comparative purposes in the study of certain systems. The names of the various structures and their important parts are printed in bold-faced type on the left margin, facilitating the students' work. Frequent drawings depict those structures that are usually difficult for pupils to locate.

The short manual by Dr. Gray is intended for a half-year course, and presents only the barest essentials. Each organ system is completed in three forms, *Squalus*, *Necturus*, and *Felis*, before proceeding to the next system. There are neither drawings nor indices.

HANDBOOK OF HISTOLOGICAL AND CYTOLOGICAL TECHNIQUE.

By R. R. Bensley and S. H. Bensley. University of Chicago Press, Chicago. $2.00. 11 x 8⅝; viii + 167; 1938.

Students who have been fortunate enough to learn the art of slide-making at first-hand from Professor Bensley have wished for a single published account of his methods; and students who have had no such good fortune—practising the art perforce without benefit of Bensley—have even more reason to wish for a comprehensive account of his techniques. And here it is, at long last. Here, in a handbook designed particularly for beginners, and containing therefore much that is conventional as well as much that has been specially devised in the anatomy laboratories at the University of Chicago, are some of the original, unpublished methods of Dr. R. R. Bensley. Being an introductory laboratory guide, this handbook deals of course with protoplasmic units as large as cells and tissues, but it seeks to lay its main emphasis on the subcellular constituents of living matter, in the investigation of which the author has been a pioneer.

Credit for the compilation of these methods adopted, developed, and devised in Dr. Bensley's laboratory is evidently intended to go solely to his daughter-in-law, who is an instructor in the laboratory in which the senior author is now professor emeritus. Her name, at any rate, appears alone after the preface.

THE PRIMATE THALAMUS.

By A. Earl Walker. University of Chicago Press, Chicago. $3.00. 9 x 6; xxiii + 321; 1938.

In his research on the thalamus, its gross and nuclear structure, its afferent connections, its relationship to the cerebral cortex, and the relationship of the geniculate bodies to the cerebral cortex, the author used the macaque monkey (*Macaca mulatta*) as his experimental material. The author's purpose is to elucidate the rôle of the thalamus in sensation, and this particular subhuman primate was selected for experimentation "because its thalamus is representative of the primate series and in many ways comparable to that of man".

Although the greater part of the monograph is devoted to the elucidation of the thalamocortical connections, the many experiments include all of the various relationships and connections of the thalamus. Also, the author reviews in great detail, its anatomical, physiological, and clinical significance.

In addition to a brief historica introduction, the text proper carries an extensive review of past and current literature. The monograph is profusely illustrated, and the extensive bibliography is divided, according to subject matter, into seven parts, each of which is placed with its respective chapter. There are two indices—author and subject.

OREILLE INTERNE. *Etude anatomo-pathologique et clinique. Technique histologique et expérimentale. 2e Edition.*

By Ch. Claoué. Editions N. Maloine, Paris. 30 francs. 10 x 6½; x + 227; 1938 (paper).

The inner ear is so complex a structure that throughout the world there are only a few men who are really familiar with its anatomical and pathological characteristics, and fewer yet have any adequate knowledge of its physiological function. The condensed description of the anatomy, pathology and histology of the inner ear as given here bring out more than anything else this state of ignorance. Written very clearly but with only passable illustrations this monograph will serve to give the otologist as well as the anatomist some idea of what it is all about. More than that it cannot do because the author has limited himself to the usual general

textbook statements and although he cites the fundamental literature on the subject, has omitted all references to the studies of the past decade, particularly those made in this country.

SURFACE AND RADIOLOGICAL ANATOMY. *For Students and General Practitioners.*

By Arthur B. Appleton, William J. Hamilton and Ivan C. C. Tchaperoff. William Wood and Co., Baltimore. $5.50. 9½ x 6½; xi + 311; 1938.

The aim of this book is to provide an introduction to the study of features which are accessible to examination in the living subject. Besides the use of physical examinations, the authors have added radiology and have attempted, by the use of extensive illustrations, "to supply a means of coördinating radiological anatomy with those features which can be determined by external examination and with those details which can be determined only by dissection."

The more complex radiographs are supplemented by anatomical drawings to facilitate their interpretations. The book is divided into five sections, each describing certain areas of the body. There are several blank pages for notes as well as an appendix on ossification and one on muscle innervation. A useful treatise.

PHYSIKOCHEMISCHE GRUNDLAGEN DER HISTOLOGISCHEN METHODIK.

By K. Zeiger. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 10.50 (paper); RM. 11.25 (cloth). 8¾ x 6; xi + 202; 1938 (paper).

This volume of the *Wissenschaftliche Forschungsberichte*, edited by R. E. Liesegang, is an important contribution bringing together the most important and definitive published material on the physical and chemical factors underlying histological techniques. It is profusely documented, mostly with the work of investigators of continental Europe, although English and American authors are also represented. An author index and a very comprehensive table of contents have been provided. It should be useful as collateral reading.

AIDS TO EMBRYOLOGY. *Third Edition.*

By Richard H. Hunter. William Wood and Co., Baltimore. $1.25. 6¼ x 3⅞; vii + 178; 1938.

In the revision of this little book (cf. notice of second edition in Q. R. B., Vol. 10, No. 3) the general arrangement has been retained and it remains a short account of the more important changes which are known to occur in development. The descriptions are so arranged that the student "will learn quickly to appreciate the signification of the common abnormalities found in the dissecting rooms and of those anomalies of development which are seen in the obstetrical wards."

PRACTICAL ANATOMY OF THE RABBIT. *An Elementary Laboratory Text-Book in Mammalian Anatomy. Sixth Edition.*

By the late B. A. Bensley. Revised and edited by E. Horne Craigie. P. Blakiston's Son and Co., Philadelphia. $3.00. 8½ x 5¾; 320; 1938.

In the revision of this well-known text (cf. Q. R. B., Vol. 2, No. 3 for previous review) Professor Craigie has kept the essential features unchanged but has carried out rather extensive revision in order "to make the text easier for the beginner to understand while, at the same time, making it more complete, more precise, and more up to date."

PHYSIOLOGY AND PATHOLOGY

DIET AND CANCER: *An Experimental Study.*

By N. Waterman. D. B. Centen's Uitgevers-Maatschappij, Amsterdam. Fl. 4.25 ($2.50). 9½ x 6¼; 96; 1938.

The question of nutrition can no longer be neglected in cancer research. This question can, in the author's opinion, never be solved by social and clinical observations but only by experimentation. The effect of different diets should be studied on animals developing tar cancer. Experiments dealing with transplanted tumors cannot possibly give information about spontaneous tumor formation. With tar cancer the effect of diet on both

carcinogenesis and course of the process can be studied. Therefore the author made a series of experiments with mice developing cancer after tarring and reached the following conclusions: (1) One must distinguish between the substances favoring the outbreak of carcinoma and those increasing malignancy. Applied to human conditions this means that prophylactic and therapeutic diets do not necessarily coincide. (2) The value of the metastasis incidence cannot be stated easily. A method is described which will express numerically the metastasis incidence in its relation to the degree of malignancy. (3) Among the classical foodstuffs (proteins, carbohydrates, and fats) only the animal fats seem to have a frankly deleterious effect; the unfavorable influence of cholesterol seems to be due to the cholesterol ethers. (4) As regards the vitamins, a comparison between the action of vitamin A or the provitamin (carotene) in arachis oil and that of the same provitamin in olive oil shows that one has to be very careful in vitamin experiments, as the vehicle may be far from indifferent. Carotene in arachis oil seems to have a favorable effect and would especially appear to diminish the metastasis number; this was not the case when carotene was dissolved in olive oil. The unfavorable effect of vitamin B_1 as described in the case of inoculated tumors is certainly not present in tar cancer. Vitamin C appears to be distinctly favorable; therefore, these results are far from supporting the notion of a tumor-favoring action of tomato juice, which contains considerable quantities of vitamin C. Further experiments on the subject are to be published soon.

NUTRITIONAL PHYSIOLOGY OF THE ADULT RUMINANT.

By Ernest G. Ritzman and Francis G. Benedict. Carnegie Institution of Washington, Washington. $2.00 (paper); $2.50 (cloth). 9⅞ x 6¾; vi + 200 + 3 plates; 1938.

By converting coarse fodders into meat and milk, the ruminant intermediates (ecologically) between man and certain humanly inedible plant sources of human food. We are told that man's exploitation of the Herbivora, and primarily of the ruminants, made possible the great numerical expansion of the human race. But, as the human population has become more dense, the population of husbanded livestock has met with increasing competition for its position, both as a consumer of cereal crops, and as the chief source of a concentrated food supply for man. The nutritional problems of today are different from those of our pioneer condition. Milk and meat we still need, and the finished animal products can be transported to market more cheaply than their ingredient feedstuffs; but the animal products are a much more costly form of human food than the raw cereals from which they are produced. The animal nutritionist must seek nowadays not only "the full potential nutritive values of the different feedstuffs," but also, and perhaps as a prerequisite, "the physiological susceptibilities of the animal itself to function as a machine under various exigencies of the food supply."

All that is a large order. Benedict and his colleagues have contributed numerous publications to the science of nutrition: in the present monograph they are concerned with the animal as a converter of energy, and also with the relation of the feedstuffs to the specific productive functions of the organism. They find that the basal metabolism of ruminants is extraordinarily variable, and that both proteins and carbohydrates have a stimulating effect on the metabolism. The components of the protein feeds is not discussed, nor is the work of Artturi Virtanen mentioned (see his "Cattle Fodder and Human Nutrition," Cambridge University Press). The present work is mainly concerned with a thesis on basal metabolism.

THE BASIS OF TISSUE EVOLUTION AND PATHOGENESIS.

By Albert A. Gray. Jackson, Son and Co., Glasgow. 7s. 6d. 9½ x 5¼; xix + 92; 1937.

The significance of some books is made as evident by the circumstances of their

publication as by their contents. This brief theoretical work, published posthumously by the author's younger son, presents the evolutionary reflections of a medical man better known for his researches on the anatomy and diseases of the ear. It outlines a theory of *induced variation*, and the evidences from otology in its support.

The evolution of a tissue, structure, or organ is hypothesized to be the result of variation occurring during the repair which follows the minute injury of a tissue already in existence. The injury is caused by a change, greater or less, in the environment, and either constantly present or present repeatedly over a very long period of time. Accompanying this tissue evolution there is a corresponding evolution of the vasomotor response in the minute arterioles and capillaries of the injured part. As generation succeeds generation, natural selection preserves "those individuals in which the fertilized ovum has the greatest potentialities for rapidly developing that tissue or structure best suited to respond to the changed environment" and, concomitantly, for developing the appropriately responding vasomotor systems. Both the new tissue and its accompanying means of nutrition become in this way involved in the common inheritance of the species, the tissue character and its vasomotor support being both subject to genetic variation.

Examples are found in the organ of hearing: an example of inheritance of defect of structure in inherited deafmutism, and an example of inheritance of defect in the vasomotor response in inherited otosclerosis. The theory is derived from the author's otological investigations, which then are used for exemplification.

VITAMIN B_1 (THIAMIN) AND ITS USE IN MEDICINE.

By Robert R. Williams and Tom D. Spies. Macmillan Company, New York. $5.00. $9\frac{1}{4}$ x 6; xvi + 411; 1938.

Among the multitude of books which demand attention nowadays, it is a satisfaction to come occasionally upon one which penetrates to the present limits of knowledge. Williams and Spies seem to have written a solid, thorough work. This book aims to encompass everything that is known about thiamin, its chemical nature, and its physiological utilization.

The book is not an account of the whole vitamin B complex, of course: it deals with only one component. To make this clear, the authors present an ingenious frontispiece—a figure of an unraveling end of rope, four dated strands of which represent the isolated and synthesized components of the complex known as vitamin B. One of these is the vitamin B_1 or thiamin. The unknown factors of vitamin B are differentiated as far as they can be in the remaining strands of the rope.

The opening of chapter xi is quotable here. "It is doubtful whether the isolation and identification of any other substance in the history of biochemistry have cost as much labor as have these operations as applied to thiamin. The first gram of the pure vitamin must have cost an aggregate of several hundred thousand dollars. To mention all the names of those who have participated in some phase of the project is to call the roll of half the mature biochemists in England and the United States" as well as the Dutch, French, Japanese, German, and other contributors. Due credit to this legion of workers is given in the bibliographies at the ends of the chapters.

THE DOCTRINE OF SIGNATURES. *A Defence of Theory in Medicine.*

By Scott Buchanan. Harcourt, Brace and Co., New York; Kegan Paul, Trench, Trubner and Co., London. $2.75. $8\frac{1}{2}$ x $5\frac{1}{2}$; xiv + 205; 1938.

If this reviewer is typical of other physicians—the group whose thinking and methodology the thesis of the book is intended to modify—the book is destined to colossal failure. After struggling through 200 pages of verbiage and obscure sentence structure, the author's argument emerged, only however as through a mirror darkly. It seems that the tradition of modern medicine, rooted in its ancient heritage, has been until recent times dominated by two men, one a philosopher

(Aristotle) and one a physician (Galen). The modern development of natural science has, in some way not made quite clear to this reviewer, "revised the tradition". Two possibilities suggest themselves to the author: "—to smash the tradition and allow the full play of the laboratory", or—the choice of the author—" . . . to recover the doctrines of the tradition". To do this the author suggests two steps. The first step is to rebuild the non-mathematical structures of the natural science, and cannot be taken, "except by a genius, without a thorough knowledge of Aristotelian logic, metaphysics and physics." The second step is "even more difficult", i.e. the "rationalizing of modern science as it actually goes on." The writings of Galen are suggested as a model.

We are neither amused nor instructed by this verbose and feeble attempt to revive the authoritarian obscurantism of the Dark Ages.

TEXTBOOK OF COMPARATIVE PHYSIOLOGY. *Second Edition.*

By Charles G. Rogers. McGraw-Hill Book Co., New York and London. $5.50. 9 x 6; xviii + 715; 1938.

AN INTRODUCTION TO HUMAN PHYSIOLOGY. *Second Edition, Revised.*

By Lathan A. Crandall, Jr. W. B. Saunders Co., Philadelphia and London. $2.00 $7\frac{3}{4}$ x $5\frac{3}{8}$; 356; 1938.

A TEXTBOOK OF GENERAL PHYSIOLOGY FOR COLLEGES. *Third Edition.*

By Philip H. Mitchell. McGraw-Hill Book Co., New York and London. $6.00. 9 x 6; xviii + 853; 1938.

LABORATORY MANUAL OF GENERAL PHYSIOLOGY. *First Edition.*

By Philip H. Mitchell and Ivon R. Taylor. McGraw-Hill Book Co., New York and London. $1.50. 9 x 6; xv + 142; 1938.

The major part of the first of these books listed (cf. Q. R. B., Vol. 2, No. 4 for mention of first edition) has been rewritten in order to incorporate all the important advances which have been made since the earlier edition appeared. In its new form it is more the nature of a textbook and less of a handbook for investigators. Much material is here presented for the first time in textbook form.

The new edition of the Crandall text (first edition noted in Q. R. B., Vol. 10, No. 2) adheres to the original plan of presenting the fundamental principles of physiology in such a way that the student beginning his college course will not be lost in a mass of detail and will acquire a thorough working knowledge of the behavior of the body as a whole and of the function of its parts. The revision consists of changes where necessary and the addition of new material.

Extensive changes in the third book listed (cf. second edition, Q. R. B., Vol. 8, p. 233) have been made, especially in connection with excitation, contraction, chemical transmission, structure of membranes, the permeability of cells, physiological oxidations, the chemistry of muscle, the vitamins and the hormones. There are new sections on the organizers or evocators, oxidation-reduction potentials, Liesegang phenomena, and the physiological study of temperature characteristics.

The manual of experiments is planned for use in connection with the textbook by Mitchell, but it may well be used with any other physiology text in developing a first year course. The number and variety of problems is such that the manual may be adapted to suit the method and interest of any professor, as well as the needs of any class of students. The book is well illustrated and indexed.

THE CULTURE OF ORGANS.

By Alexis Carrel and Charles A. Lindbergh. Paul B. Hoeber, Inc., Medical Book Department of Harper and Bros., New York. $4.50. $9\frac{1}{4}$ x $6\frac{1}{8}$; xix + 221 + 38 plates; 1938.

It seems likely to this reviewer that every interested reader of American newspapers and news periodicals must have heard of this book by now. It has been most widely noticed. It is chiefly a description of an apparatus (notably the Lind-

bergh pump) and of a technique (notably Dr. Carrel's) by means of which whole organs have been cultured *in vitro* after isolation from an organism. The achievement of this methodological objective marks the culmination of a promising branch of biological experimentation which is century-old in its inception. The method is a resultant of the efforts, first, of the physiologists to develop a satisfactory substitute for the normal life-sustaining environment of the organs, and, second, of the tissue-culturists and bacteriologists to bar life-destroying microörganisms from cultures of living matter.

There can be no doubt that the method provides a powerful instrument for biological investigation. There is no lack of faith or enthusiasm on the part of the authors as to the possibilities of further developments.

SPECTRO-BIOLOGY.

By Maryla de Chrapowicki. C. W. Daniel Co., Ltd., London. 3s. 6d. $8\frac{3}{4}$ x 5; 5 + 62; 1938.

When one is faced with the startling fact that within a 62 page thesis, the author is going to:

> (1) Establish a definite proof that light is the only biological factor which controls every aspect of physical existence; (2) Offer a method whereby we can calculate with absolute precision what the normal biological factor of each individual body should be and how to control the structural integrity of a form; (3) Show that health is a purely biological state and a direct result of radiation, while disease is but a relative condition not pathological in itself; (4) Prove that there is a changeless universal method of diagnosis whereby we can not only determine the cause of a disease, but which enables us to preserve a normal state of health in such a perfect equilibrium as to prevent disease and to promote the expansion of an individual life to reach the fullest scope of its physical existence;

one reads eagerly—but alas, he is overtaken by disappointment ere he has finished the first sentence.

The concensus of opinion of the American medical profession concerning light and color therapy has been expressed previously in several journals, and in each case the proponents of chromo-therapy are considered in the same category with all the other quacks and faddists in the profession. The strain placed upon one's common sense in trying to believe that a person born at 4:30 P.M. on April 14 has only to have his face and head treated to cure him of appendicitis is so great that we are inclined to disagree with the statement of the publisher on the inside front cover that "*Spectro-Biology* will be counted as one of the most important medical books of the year".

INTOXICATIONS ET CARENCES ALIMENTAIRES.

By Maurice Loeper, E. Bioy, J. Cottet, M. Debray, R. Degos, L. Duchon, G. Garçin, E. Gilbrin, A. Lemaire, A. Lesure, G. Marchal, J. L. Parrot, M. Perrault, P. Soulié, R. Turpin and A. Varay. Masson et Cie, Paris. 60 francs. $9\frac{3}{4}$ x $6\frac{3}{4}$; viii + 259; 1938 (paper).

An introductory chapter by Professor Loeper outlines the thesis which he has maintained for some time relative to the causes, signs and treatment of those digestive disturbances which apparently have no organic foundation. The abnormal and excessive reactions of the intestinal and gastric mucosa to generally innocuous foods, manifest in gastric upsets such as pain, flatulence, and diarrhea, are considered by him as a syndrome which he calls digestive hypersensitivity. He notes, in addition, that such hypersensitivity can be demonstrated by a subcutaneous injection test that he has devised. The treatment he advocates consists mainly of dietary precautions. The remaining chapters of this book are the contributions of several students and associates who discuss with relation to this idea the anatomy, physiology and biochemistry of the digestive tract. Each of the articles is characterized by a sound general review of the literature on the subject, but none contains bibliographic references. Loeper's views are interesting but it is obvious that he and his associates have only begun to investigate their implications, some of which may be important for the study of human variability.

ADVENTURES IN RESPIRATION. *Modes of Asphyxiation and Methods of Resuscitation.* *By Yandell Henderson. Williams and Wilkins Co., Baltimore.* $3.00. 8⅛ x 5½; xi + 316; 1938.

There are many who will not agree with some of the author's conclusions regarding asphyxiation and resuscitation but none will deny that this book is fascinating. Here are real adventures into a respiratory jungle where carbon monoxide poisoning, shock, acidosis, mountain sickness are some of the menacing predators that are encountered and battled. Dr. Henderson has his own ideas on how these enemies should be overcome and he is not afraid to voice his opinions, but he is a true scientist and presents both sides of each contention. Since his conclusions are far from being fly-by-night inspirations but based on actual experimentation, and since those which have finally received recognition have proved to be correct (as the use of carbon dioxide in the Henderson-Haldane inhalator), his side of the argument carries much weight.

The book is neatly balanced between technicality to prevent ambiguity, and simplicity to enable a high school student to understand it. All and sundry will find enjoyment and gain knowledge through its perusal.

HIGH BLOOD PRESSURE AND LONGEVITY *and Other Essays Selected From the Published Writings of David Riesman.* *By David Riesman. John C. Winston Co., Philadelphia.* (Not for sale.) 9 x 6; xii + 726; 1938.

Friends and admirers of Professor Riesman on the occasion of his seventieth birthday in 1937 selected some 80 of his papers and have republished them in this volume. The articles deal with a variety of topics in clinical medicine, pathology, and the history of medicine. They have been arranged in sections dealing respectively with reports on diseases of the cardiovascular system, lungs, gastrointestinal tract, nervous system, and endocrines. In order, these are followed by papers on infectious diseases, diagnostic signs, and medical history. The title of this collection derives from a well-known paper published in 1931 in which Riesman discussed the diagnosis and care of hypertensive patients and emphasized that hypertension is compatible with longevity.

It is apparent that a happy choice has been made in selecting the representative writings. On the whole, they bring out Riesman's wide range of interests in the field of clinical medicine and, most of all, the wisdom which has characterized his long and active life as a clinician and teacher.

DAS ZWISCHENHIRN UND DIE REGULATION VON KREISLAUF UND ATMUNG. *Beiträge zur Physiologie des Hirnstammes, Teil II.* *By W. R. Hess. Georg Thieme Verlag, Leipzig.* RM. 26. (25 percent discount outside of Germany). 12¼ x 8¾; [8] + 127; 1938 (paper).

The first part of this monograph was reviewed in these columns, Volume 7, page 490, under the title *Die Methodik der lokalisierten Reizung und Ausschaltung subkortikaler Hirnabschnitte.* This was confined almost exclusively to elaborate descriptions of the operative technique perfected on the brain of the cat with the aim of finding out more about the regulatory mechanism of the respiratory and circulatory systems. The present part describes some further experiments, especially with the stimulation of the thalamic and sub-thalamic regions and gives a discussion of the results. It is illustrated with electrographs and photographs and schematic drawings showing the points of stimulation. A bibliography, an index of illustrations, and subject index are included. An important contribution.

HANDBOOK OF PHYSIOLOGY AND BIOCHEMISTRY. *Thirty-fifth Edition.* *By the late W. D. Halliburton and R. J. S. McDowall. P. Blakiston's Sons and Co., Philadelphia.* $5.50. 8½ x 6; xi + 973; 1938.

The first edition of this text (senior author formerly professor of physiology, University of London, King's College, junior

author now occupying the same chair) appeared in 1848. The original author, William Senhouse Kirkes, of St. Bartholomew's Hospital, was followed by various editors up to 1896 when Professor Halliburton took charge and, in 1898, brought out the fourteenth edition. It is hardly necessary to point out that a book which has survived for ninety years and now appears in its thirty-fifth edition has, in the process of evolution, kept abreast of the times at each emergent stage. With the present edition "Biochemistry" appears on the title page for the first time.

MAJOR ENDOCRINE DISORDERS.
By S. Levy Simpson. John Bale Medical Publications, London. 10s. 6d. 7¼ x 4¾; x + 184; 1938.

This small book offers an excellent clinical summary of the endocrinopathies. The subject matter is well organized, and the presentation is concise. The syndromes associated with malfunction of each of the endocrine glands are considered from the point of view of pathology, incidence, clinical picture, diagnosis, course and prognosis, and treatment. There is some theoretical discussion, particularly of the pituitary-adrenal-gonadal complex, but on the whole the material is restricted to facts of immediate clinical significance. A tabulation of some of the hormones on the market today, particularly of the British drug houses, is given in the appendix. There is an adequate index.

THE PITUITARY GLAND. *An Investigation of the Most Recent Advances. Association for Research in Nervous and Mental Disease. Vol. XVII of a Series of Research Publications. Proceedings of the Association, New York, December 28th and 29th, 1936.*
Edited by Walter Timme, Angus M. Frantz and Clarence C. Hare. Williams and Wilkins Co., Baltimore. $10.00. 9 x 6; xxiv + 764; 1938.

This publication contains the Proceedings of the Association for Research in Nervous and Mental Disease at the meeting in New York in December, 1936. The material, which consists of 42 separate papers relating to the structure and function of the pituitary gland, is presented in three sections. Sections I and II are concerned respectively with the anatomy and physiology of the gland. Section III, General considerations, is primarily clinical in subject-matter. The book is thus a very comprehensive survey of present-day knowledge of the pituitary. Each chapter is followed by a pertinent list of references. The book is well illustrated and indexed.

ABC OF THE VITAMINS. *A Survey in Charts. By Jennie Gregory. Foreword by Walter H. Eddy. Williams and Wilkins Co., Baltimore.* $3.00. 11½ x 9; xii + 93; 1938.

In this work the author attempts to bring the scattered, intricate facts concerning the controversial field of vitamins into a coherent whole by the restrained use of carefully constructed graphic diagrams. She presents by this method a history of the work upon vitamins, the results of research upon each of the vitamins, the scientific methods employed and the general relations which exist in the field. Without the sacrifice of scientific accuracy or clarity, the book summarizes in a brief space and interesting manner the fundamental problems and results of vitamin research. This book is symptomatic of the extension into university life of the general evolutionary trend towards complete illiteracy that is so rapidly accelerating among human beings in general, as a result of movies, picture magazines, and similar agencies. Why should a biologist ever learn to read, with Miss Gregory's services at command?

BEAUTY PLUS. *The Smart Woman's Key to Beauty, Health and Charm.*
By Mary MacFadyen. Illustrated by Frank N. Netter. Emerson Books, New York. $1.96. 8⅛ x 5½; 272; 1938.

Besides the many obvious trivialities and hints about sex appeal and personality that help pad out these pages, this simply written book contains a wealth of prac-

tical, if sometimes obvious, hints and common sense information. Among its pages are scattered 66 formulas for beauty aids with the approximate cost of the ingredients and instructions for mixing them. This well-indexed and amusingly illustrated volume not only covers every phase of beauty treatment, but also supplies the reader with home cures for hangovers, constipation, and a variety of other unladylike ailments.

ZEITSCHRIFT FÜR ALTERSFORSCHUNG. *Organ für Erforschung der Physiologie und Pathologie der Erscheinungen des Alterns, Bd. 1.*

Edited by Emil Abderhalden and M. Bürger. Verlag von Theodor Steinkopff, Dresden and Leipzig. Annual subscription RM. 30. 9½ x 6⅝; 88; 1938.

This is a new periodical devoted to the publication of research on growing old, predominantly from the physiological and clinical standpoints. In the present issue there are no investigations treating longevity (or other problems concerned with age) in a statistical manner. Most of the articles deal with clinical observations on old age or physiological-chemical changes with ageing.

MATERNAL CARE COMPLICATIONS. *The Principles of Management of Some Serious Complications Arising during the Antepartum, Intrapartum, and Postpartum Periods. Approved by The American Committee on Maternal Welfare, Inc.*

Edited by F. L. Adair. Prepared by R. D. Mussey, P. F. Williams and F. H. Falls. University of Chicago Press, Chicago. $1.00. 7⅝ x 5⅛; vii + 95; 1938.

A condensed discussion of the classification, symptoms, treatment and prognosis of toxemias of pregnancy, obstetric hemorrhages, and puerperal infections is presented in this booklet. It is clearly and competently written and in general outlines the conclusions and views accepted by the specialists in the field. There is neither index nor bibliography.

A TEXT-BOOK OF THE DISEASES OF THE SMALL DOMESTIC ANIMALS. *Third Edition, Thoroughly Revised.*

By Oscar V. Brumley. Lea and Febiger, Philadelphia. $4.75. 7⅞ x 5⅜; 597; 1938.

The third edition of this text (2nd. edition reviewed in Q. R. B., Vol. 7, No. 2) for students and guide for the practitioner has been brought up to date, some of the sections being entirely rewritten and others changed to conform to recent advances in knowledge. The section on diseases of the fowl has been eliminated. A detailed index adds much to the book's usefulness.

BIOCHEMISTRY

BIODYNAMICA. *A Scientific Journal for the Elaboration and the Experimental Study of Working Hypotheses on the Nature of Life. Volume 1.*

Edited by Basile J. Luyet. Biodynamica, Normandy, Mo. $6.00 per volume. 9⅞ x 6⅞; iv + 392; Numbers 1–2, October, 1934; Numbers 3–8, June, 1935; Numbers 9–15, March, 1936; Numbers 16–24, December, 1936; Numbers 25–28, August, 1937; Numbers 29–32, December, 1937; Number 33, April, 1938. (paper).

Researchers in the physical sciences have used with a great deal of success a method of study beginning with mathematical speculation and ending in experimental verification. Luyet and his associates are following the physicist's method of "working hypotheses" and have founded "*Biodynamica* for the publication of papers dealing with *working hypotheses on the nature of life* and *with the experimental study of these hypotheses.*" The founders of this publication wish to solicit the collaboration of all those interested and will accept papers in any of the languages recognized for scientific publication. Unverifiable speculations will not be printed in *Biodynamica.* Each accepted article is treated as a separate pamphlet with its own issue number and pagination.

Biodynamica is not a periodical publication and is issued only as material develops. Over a period of four years, October, 1934 to April, 1938, a total of

33 papers has been published. Luyet and his collaborators have written about forty-two per cent of the total experimental researches printed over this period of time. In the first issue of *Biodynamica*, Luyet states his *biocondensation* hypothesis "according to which the fundamental living units, which are supposed to be some formed constituents of the cell, especially the chromosomes, possess a particular physical structure in which matter is more concentrated than in the ground substance of the cell, . . .", and if these living units "consist of more concentrated matter, their specific gravity, their conductivity coefficient for heat and electricity, their heat capacity, their coefficient of transparency for all the radiations—in general, all their physical properties—should be different from the properties of the ground substance of the cell." Also the physical properties of living matter should be different from what they are in dead matter. Following this line of thought, many articles containing alleged experimental verifications of the biocondensation hypothesis have been published.

On *Biodynamica's* cover there are two emblematic figures placed side by side in conjunction with each other. The figure on the left side represents the modern conception of an atom of carbon with a positively charged nucleus and six negative electrons, two in an inner orbit and four in an outer orbit; the symbol on the right represents a mitotic figure, evidently in metaphase. Together the symbols are supposed to express the publication's program, "which is to disclose the interrelationships between physical chemistry and biology."

INTRODUCTION TO PHYSIOLOGICAL CHEMISTRY. *Fourth Edition.*

By Meyer Bodansky. John Wiley and Sons, New York; Chapman and Hall, London. $4.00. 9 x 5⅞; ix + 686; 1938.

LABORATORY MANUAL OF PHYSIOLOGICAL CHEMISTRY. *Fourth Edition.*

By Meyer Bodansky and Marion Fay. John Wiley and Sons, New York; Chapman and Hall, London. $2.00. 9 x 5¾; vii + 295; 1938.

In the present edition of Bodansky's text (for previous review, cf. Q. R. B., Vol. 10, No. 3) additional space has been given such subjects as enzymes, hormones and vitamins. The subjects of digestion and the chemistry of enzymes have been given separate chapters, Dr. Oscar Bodansky having prepared the latter chapter as well as the one on physiological oxidations. Wherever possible "an attempt has been made to include in the discussion sufficient material to enable the reader to gain some appreciation of the continuity of biochemical research and to realize the stages by which the present position has been attained."

Most of the changes in the revision of the manual (third edition noticed in Q. R. B., Vol. 10, No. 3) have been made in an attempt to clarify directions and to render them more workable for the elementary student.

AIDS TO BIOCHEMISTRY. *Second Edition.*

By E. A. Cooper and S. D. Nicholas. William Wood and Co., Baltimore. $1.50. 6¼ x 3⅞; vii + 213; 1938.

OUTLINES OF BIOCHEMISTRY. *The Organic Chemistry and the Physicochemical Reactions of Biologically Important Compounds and Systems. Second Edition.*

By Ross A. Gortner. John Wiley and Sons, New York; Chapman and Hall, London. $6.00. 9 x 6; xx + 1017; 1938.

The second edition of *Aids to Biochemistry* (first edition appeared in 1937) has been partly rewritten. Chapters on hormones and hydrogen ion concentration have been added and the chapter on carbohydrates and vitamins extended. The balance between the theoretical and experimental aspects of biochemistry has been maintained so that the student can continue to use the book as a guide in the laboratory as well as for purposes of reading and revision.

The present edition of the second of these books, an excellent text, represents an extensive revision and in many instances a complete rewriting of the text. Additional chapters deal with oxidation-reduction, the flavins, the hormones, and lignin.

AN INTRODUCTION TO BACTERIOLOGICAL CHEMISTRY.

By C. G. Anderson. William Wood and Co., Baltimore. $4.00. $7\frac{1}{4}$ x $4\frac{5}{8}$; viii + 278; 1938.

This book, which the author describes as "a survey of the whole field in a form suitable for students," seems to assume a degree of antecedent knowledge which ought to make a survey unnecessary. The outgrowth of his own series of lectures to advanced students, it covers such topics as: growth factors; nitrogen and carbohydrate metabolism; proteins, polysaccharides, lipoids, and pigments of microörganisms. There is also a section on immunochemistry.

The elementary student ordinarily is satisfied with the chemistry to be found in any good textbook of bacteriology, while the advanced student will probably have more use for the two-volume Buchanan and Fulmer to which the author refers at the ends of many of his chapters. It is difficult for the reviewer to see for whom this book is written.

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume VII.*

Edited by James M. Luck and Carl R. Noller. Annual Review of Biochemistry, Stanford University P. O., Calif. $5.00. $8\frac{3}{4}$ x 6; ix + 571; 1938.

As usual the contributions (23 in number) in this volume of the *Review* represent a distinguished group of investigators and students, and cover a wide range of subjects in the biochemical field. This year, the review belonging in the group of "Topics of timely nature" is *Organic Insecticides* by F. B. La Forge and L. N. Markwood. To those who are unacquainted with the *Review* attention should be called to the valuable reference lists which accompany each section. In a science which is expanding as rapidly as this one is it is most useful to have the various subjects under discussion so well documented. The volume concludes with excellent author and subject indexes. The Editorial Committee announces the forthcoming publication of the *Annual Review of Physiology*—a companion volume to the *Annual Review of Biochemistry*. This will be a joint undertaking with the American Physiological Society.

THE CHEMISTRY OF THE STERIDS.

By Harry Sobotka. Williams and Wilkins Co., Baltimore. $8.50. $8\frac{7}{8}$ x $5\frac{7}{8}$; xiii + 634; 1938.

The first sixth of this book outlines the history of sterid chemistry, the chemical and physical properties of the bile acids, other sterids and their molecular compounds, and analytic methods. The major portion (335 pages) is a classified catalog of sterids and their derivatives recorded before January 1, 1937. In addition, the author has provided a 63-page bibliography, with references back to the text, a subject index and 404 formulas. This very useful reference work is a companion volume to the author's *Physiological Chemistry of the Bile*. These volumes carry cross-references to each other, thereby facilitating the correlation between chemical and biological progress for students of biliary secretion and hepatic function.

FORTSCHRITTE DER BIOCHEMIE. *III Teil (1931–1938).*

By Felix Haurowitz. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 9 (paper); RM. 9.75 (cloth). $8\frac{3}{4}$ x 6; xi + 167; 1938.

The earlier parts of this solid and useful work have been noted in these columns—Part I (1914–1924) in Vol. 2, p. 143, and Part II (1924–1931) in Vol. 7, p. 370. The present work covers the progress in animal biochemistry between 1931 and 1938. During this period much important work has been published in practically all the special fields of this subject, particularly on the vitamins, sex hormones, carbohydrates, proteins, and enzymes. Many of the former views and conclusions have had to be changed in accordance with the findings of the recent work included in this volume. Almost 1300 bibliographic

titles are given. Our copy is defective due to the faulty assembling of pages.

KOLLOIDCHEMIE DES PROTOPLASMAS. *Zweite, erweiterte und vollständig umgearbeitete Auflage.*

By W. W. Lepeschkin. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 18. (paper); RM. 19. (cloth). 8¾ x 6; xii + 244; 1938.

Since the appearance of this book ten years ago several textbooks on colloidal chemistry have appeared so that the author has omitted the elementary phases of this subject from the original introductory chapter. Additions to the volume include all the important researches of recent date.

BIOCHEMISTRY FOR MEDICAL, DENTAL AND COLLEGE STUDENTS.

By Benjamin Harrow. W. B. Saunders Co., Philadelphia and London. $3.75. 9¼ x 6; 383; 1938.

An excellent text on biochemistry designed for use among medical, dental, agricultural, and general college students. At the close of each chapter there is a bibliography relating to the subject matter covered within the chapter. Almost every reference is accompanied by a brief comment on its particular value.

THE CHEMICAL ORGANIZATION OF LIVING MATTER. *Second Edition.*

By C. F. Krafft, 2510 Q Street, N. W., Washington, D. C. 9 x 6; 27 + [2]; 1938 (paper).

The second edition of this pamphlet differs from the first only in the addition of a supplement of two pages entitled "*Elastic deformation of protein chemical structures.*"

THE UNIVERSITY OF COLORADO STUDIES, *Volume 25, Number 3. A Group of Papers from the Department of Chemistry.*

University of Colorado, Boulder, Colorado. $1.00. 10 x 6¾; 161–224; 1938 (paper).

SEX

LAWS RELATING TO BIRTH CONTROL IN THE UNITED STATES AND ITS TERRITORIES.

By Seymour L. Linfield. Birth Control Clinical Research Bureau, 17 West 16th Street, New York. 25 cents. 8 x 5⅜; 61; 1938 (paper).

This pamphlet of the federal and state laws concerning the dissemination of contraceptive literature is published not so much for use by legal authorities, physicians, or pharmacists, as it is for bringing to the general public the need for revision of laws which hamper the development of birth control in our country. The point in emphasis is that even though our courts are reading a liberal interpretation into our laws in order to protect those actively interested in the slogan "Every Child a Wanted Child," progress in birth control cannot be realized until Anthony Comstock's ideas are eradicated from our statute books.

SEX AND SENSE.

By T. W. Pym. Nicholson and Watson, London. 2s. 6d. net. 7¼ x 4⅞; 128; 1938.

Canon Pym discusses in order marriage, masturbation, homosexuality and winds up this work in an effort to tie it all into a rather vague chapter entitled God. Throughout the book he stresses repeatedly the need for sex education, especially by the clergy, emphasizing the lack of coöperation of the church and the need for courses on sex in theological colleges. He finds illicit relationships occurring today "that simply could not have happened 25 years ago," and blames most of today's immorality on birth control. Broadmindedly, however, he admits that contraception may have its place in marriage and the planning of children. Although not caring for the postponement of the first arrival, Canon Pym believes that even this might have its good points from a scientific angle since: "the parents would become more practised; the calmer attitude of the mother might be better for the unborn child."

ATTAINING MANHOOD. *A Doctor Talks to Boys about Sex.*

By George W. Corner. Harper and Bros., New York. $1.25. $7\frac{1}{4}$ x $4\frac{3}{4}$; xi + 67; 1938.

This little book provides straightforward information for the maturing boy. In about sixty pages Dr. Corner attains his objective, namely to write a book about sex suited to the intelligent boy of high school age. There is none of the sensationalism or sensualism that graces more pretentious volumes, nor are there any boring examples taken from the bees and flowers which are in great favor with those people advocating educational methods of teaching sex. Any parent of a growing boy would do well to supply him with this book. The illustrations are very good.

THE TECHNIQUE OF CONTRACEPTION. *An Outline. Fourth Edition.*

By Eric M. Matsner. Foreword by Frederick C. Holden. National Medical Council on Birth Control, 501 Madison Ave., New York. Complimentary copies can be obtained by physicians by writing to the National Medical Council on Birth Control. 9 x 6; 50; 1938.

A brief summary of methods in the technique of birth control. This edition incorporates all recent developments which the medical profession has accepted as therapeutic measures and public health policies.

BIOMETRY

MATHEMATICAL BIOPHYSICS. *Physicomathematical Foundations of Biology.*

By Nicolas Rashevsky. The University of Chicago Press, Chicago, Illinois. $4.00. $9\frac{1}{2}$ x $6\frac{1}{2}$; xvii + 340; 1938.

This book has for its main objective to lay the foundations of a systematic mathematical biology which will have to biology the same relation that mathematical physics has to physics. The subject is introduced with a consideration of the cell, a hypothetical spherical cell to begin with. The equations to describe the inward and outward diffusion and the necessary conditions for the equilibrium of the system are then outlined and developed. From this, the author proceeds to the examination of situations in which the cell is deformed and the metabolism becomes altered and thus is enabled to arrive at a mathematical expression for cell division. This first part concludes with a tentative formulation of a theory of organic form. In the second part of the book the author discusses problems of physiology and psychology: nervous irritability, excitation, inhibition and conduction, reflex actions, learning and thinking. The solutions advanced for these problems have required great ingenuity and depend much on postulates that for the present cannot be verified experimentally. This, of course, is the main difficulty which is met when one attempts to draw practical consequences from or to make use of the ideas expressed in logical or mathematical theorizing. The same difficulty has been encountered in the application of mathematical rationalizations to problems of economics or population. Often enough it has been found that the general though elegant formulations express only what has been postulated and this must be accepted on faith. It is too early to judge the biological value of the author's work. For the time being it can only serve as an additional source of ideas for more observations and experiments.

LABORATORY MANUAL AND PROBLEMS FOR ELEMENTS OF STATISTICAL METHOD.

By Albert E. Waugh. McGraw-Hill Book Co., New York and London. $1.50. 9 x 6; x + 171; 1938.

This manual is a useful complement to many of the well-known textbooks on the application of statistical methods and especially for that by the author. In the first section there are a great many of the usual statistical tables as useful time-savers. Many of these are taken from other authors, but some have been computed especially for this manual. For instance, tables A 9 and A 10, concerning conversion from probable error to standard

error and inversely, may save the time of the laboratory worker. "The wise statistician soon learns that there are various methods by which he can reduce the amount of purely arithmetical work." In the other sections the most useful statistical formulae (without mathematical derivation), and many examples and exercises in the application of statistical methods are given.

A Statistical Study of the Rattlesnakes. *V. Head Dimensions. Occasional Papers of the San Diego Society of Natural History, Number 4, May 31, 1938.*

By Laurence M. Klauber. San Diego Society of Natural History, San Diego, Calif. 15 cents, postpaid. $8\frac{3}{8}$ x $5\frac{3}{8}$; 53; 1938 (paper).

The author of this paper presents a very thorough statistical study of head and body lengths of some 6000 of the western species of rattlesnakes, and points out the advantages and disadvantages of employing these characters as differential criteria. There is a simple linear relationship between head length and body length within a given species, and this relationship varies enough among certain species to be of practical value in classification. The head length-body length relationship in general, however, varies with age and sex to such an extent that the author believes it should not be used alone, but only in substantiating classification based on other taxonomic criteria.

Tables of the Ordinates and Probability Integral of the Distribution of the Correlation Coefficient in Small Samples.

By F. N. David. Biometrika Office, University College, London. 10s. $10\frac{7}{8}$ x $8\frac{1}{2}$; xxxviii + [6] + 55 + 2 charts; 1938.

The tables give the ordinates and areas of the curves representing the sampling distribution of the correlation coefficient for differing values of n and any population correlation, ρ. The computation of the tables was suggested by Karl Pearson in 1931, and the book forms a further complement to the well-known *Tables for Statisticians and Biometricians.*

PSYCHOLOGY AND BEHAVIOR

Popular Psychological Fallacies.

By James G. Taylor. C. A. Watts and Co., Ltd., London. 7s. 6d. net. $8\frac{1}{2}$ x $5\frac{1}{2}$; vii + 275; 1938.

This is a collection of essays dealing with different phases of psychology. Each chapter is complete in itself and independent of the others. They are not equally meritorious.

Within the past generation a multitude of new schools of psychological thought have arisen, and since one cannot accept them all an impartial criticism is helpful. Although the only psychologists mentioned by name whose theories have been subjected to such an analytical criticism are William James and Siegmund Freud, the present reviewer is inclined to suspect that Rudolf Eucken was in the back of the mind of the author while writing much of this book.

Among the subjects discussed are laboratory technique (an excellent discussion, by the way), the number of the senses, the relation between the mental and physical universes (rather unhappy, because no convincing conclusions are reached, but it is not fair to condemn the author for failing to arrive at a solution of the mystery that has baffled all the great intellects of history), race prejudice, militaristic propaganda, the Bolshevik purge, the political dictatorships, Buchmanism, and personal conversion. The author's views on these and many other subjects are likely to stimulate the reader's thought, especially if he doesn't agree with them. There is no index.

The Behavior of Organisms. *An Experimental Analysis.*

By B. F. Skinner. D. Appleton-Century Co., New York and London. $5.00. $8\frac{3}{4}$ x 6; ix + 457; 1938.

The behavior of the white rat is here completely analyzed in a quantitative

manner. The rats were placed in uniform cages each of which contained a lever placed within the natural reach of the rodent's paws. Every time the lever was pressed the action was automatically recorded. The records were then collected and studied and the conclusions that were derived were therefore based on data obtained in an objective manner with personal interpretations eliminated.

The term system as applied by the author "consists of an aggregation of related variables, singled out for the sake of convenient investigation and description from all the various phenomena presented by a given subject matter." He then goes on to state that confusion among current systems of behavior is the result of no agreement as to what the principal variables in behavior are, or as to their precise definition. These faults have been corrected.

Although the rat is the exclusive experimental organism treated in this book, its behavior has far reaching implications which may well apply to the behavior of man.

PSYCHOLOGICAL DEVELOPMENT. *An Introduction to Genetic Psychology.*

By Norman L. Munn. Houghton Mifflin Co., Boston. $3.25. 8½ x 5⅝; xx + 582; 1938.

Dr. Munn, Professor of Psychology at Vanderbilt University, states in his foreward that he has attempted "to sketch the chief trends of racial and individual psychological development in a manner which will make these understandable to undergraduate students of psychology and education." The scope of the material and ideologies which he covers in realizing his objective is so tremendous that he is forced to resort to condensation which the beginning student may find bewildering and the more advanced student superficial. The fundamental viewpoint is biological and the subject matter which terminates in a discussion of human personality changes from adolescence to senescence is, in the beginning, devoted to a presentation of the main facts of cytology, genetics, the phylogenesis of unlearned behavior, and the evolution of intelligent behavior. The facts of human behavior are then reviewed: prenatal, postnatal, intellectual, emotional, and social. Two chapters are devoted to language functions. The organization of material in chapters and sections and the literary style are in the academic tradition. There is a bibliography of approximately 1000 pertinent references, an index of authors and an index of subject matter.

HUMAN POWERS AND THEIR RELATIONS.

By K. W. Monsarrat. Hodder and Stoughton, Ltd., London. 10s. 6d. 10 x 6½; vii + 289; 1938.

In this, the second volume of a series, Monsarrat continues to develop his philosophy of interpretation of human behavior. The main features of his thesis are (1) man should consider himself and his fellow-beings as "powers" or dynamic entities, (2) societies constitute "power-units" of the same order and variation in their characteristics is determined by differences in organization, (3) the powers and power-units tend continuously to achieve a state of equilibrium and thus human social behavior is stimulated. In this volume an attempt is made to illustrate these concepts with examples taken from physics, chemistry and biology, human and otherwise. Although this may be regarded as a profound work, at least from the standpoint of introspective social psychology, it suffers greatly from prolixity, lack of clarity and a unique terminology. It must also be noted, that stripped of their peculiar verbal expressions, the main ideas are not quite original. One needs only recall, for example, the work of the mathematical economists such as Pareto, Walras and others to find similar concepts.

PSYCHIATRIE MÉDICALE, PHYSIOLOGIQUE ET EXPÉRIMENTALE. *Séméiologie—Thérapeutique.*

By H. Baruk. Masson et Cie, Paris. 220 francs. 9¾ x 6¾; 827; 1938 (paper).

This book by the French psychiatrist Baruk is the result of fifteen years of work, experimental and clinical, in the psychiatric field. The viewpoint, typical of the

French school of psychiatry, is predominantly organic. The subject matter is presented in four parts. Part I is devoted to a discussion of the psychiatric conditions associated with known organic defects (tumors, infection, circulatory disturbances). Catatonia and hysteria, with experimental work related to each, are included in the first part. Part II is concerned with the various clinical phenomena associated with psychoses and psychoneuroses. Chapters are devoted to disturbances of sleep, psychomotor activity, thinking and visceral function. In Part III, the question of treatment is reviewed. In the last part, problems related to the organization and administration of a psychiatric hospital are discussed. There is an excellent bibliography of 628 titles and a subject index.

INTRODUCTION TO METHODS IN EXPERIMENTAL PSYCHOLOGY.

By Miles A. Tinker and Kenneth H. Baker. D. Appleton-Century Co., New York and London. $2.75. 10¾ x 8¼; vii + 222 + 4 plates; 1938.

This manual is designed to meet the needs of instructors who desire to give large classes of beginning students a laboratory training in the basic principles of experimental methods of psychology. It subordinates studies of perception, memory, and psychophysics in order to interest the students in the contemporary problems of learning and personality.

The spiral binding facilitates ease in handling, and the book in general is most efficiently constructed; it includes graph paper, photographs for use in emotional studies, explanatory text material, and a bibliography. Its final value, however, will lie in the ability of the individual instructor to surmount the crystallized and predigested aspects of the work.

INTRODUCTION TO GENERAL PSYCHOLOGY.

By James B. Stroud. Prentice-Hall, Inc., New York. $3.25. 8 x 5⅝; xv + 681; 1938.

Dr. Stroud of the Kansas State Teacher's College attempts to present "some of the basic facts and major explanatory concepts of behavior". Included in this volume's nearly 700 pages are discussions of instinct and culture; personality; sensory, perceptual, and learning processes; and memory and intelligence. The work is amply illustrated with charts of results, diagrams of apparatus and nerve processes, and photographs of outstanding psychologists.

The book is limited by its scanty bibliography of "selected references," its singleness of viewpoint, and its looseness of organization which rambles to a forbidding length as an introductory text. On the other hand, it has not been "popularized".

A LABORATORY MANUAL IN GENERAL EXPERIMENTAL PSYCHOLOGY. *Revised Edition.*

By Norman L. Munn. Prentice-Hall, Inc., New York. $1.90. 11 x 9; viii + 286; 1938 (paper).

This manual—devised to acquaint students with the experimental investigation of outstanding current psychological problems—does not represent any particular school of psychology to the exclusion of others. Objectivity is stressed throughout. In the revision those changes which teaching experience has indicated have been made. A useful laboratory guide.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE MIND OF THE ANCIENT WORLD. *A Consideration of Pliny's Natural History.*

By H. N. Wethered. Longmans Green and Co., London and New York. $4.00. 8½ x 5¾; xv + 302; 1937.

Pliny's object in writing the *Natural History* was to produce an exhaustive compendium setting forth everything that was known about the natural world. He obtained his material from three sources—his own personal observations, the written record of earlier observers, chiefly Aristotle, and the tales brought home by soldiers and sailors of the Roman legions who had seen service in foreign parts. The information from the first two sources was quite authentic, but unfortunately the soldiers and sailors of that day were

like those of today in that they took such delight in astonishing those who stayed at home with the tales of their adventures.

The entire work is not so much a description of the world as of what Pliny's contemporaries thought about the world. In it Pliny states the superstitution (that is still popular today) that a puppy whose tail is bitten off can not go mad, and he speaks of rain-storms of milk, blood, wool, tiles, bricks, frogs, and fish, in all of which he is quite skeptical. His account of the olive trees that marched across the highway to plant themselves in a new locality as an omen of dire events to come in the reign of Nero takes up more space than his discussion of the commercial uses of olive oil, and his discussion of jewels emphasizes their use in quack medicine rather than in the arts.

This is not, however, so much the place to discuss Pliny's work as Mr. Wethered's interpretation of it. Much of it consists of direct quotation, but there is also a great deal of comment on unquoted parts, and these are liberally interspersed with quotations from later writers, to the extent of their indebtedness to the Natural History. For instance he believes that Shakespeare's knowledge of animate nature was derived almost entirely from Pliny.

It has been commonly stated that Pliny met his death while making a scientific study of Vesuvius in eruption. An entry in his note book is the basis of this belief. But Pliny the younger tells us that when his uncle arrived at the stricken area he was so impressed by the scenes of devastation that he threw himself wholeheartedly into the task of evacuating the victims of the cataclysm, and while engaged in this work of mercy was overcome by the poisonous fumes from the volcano.

There is an intensely interesting appendix discussing the natural science of the middle ages, and an index of ten pages.

AN ORIENTATION IN SCIENCE. *First Edition.*

By Ten Members of the University of Rochester Faculty. C. W. Watkeys, Editor. H. A. Alling, W. Berry, R. G. Daggs, F. W. Fairbanks, R. W. Helmkamp, J. E. Hoffmeister, C. Stern, R. P. Tittsler, W. E. Van de Walle. McGraw-Hill Book Co., New York and London. $3.50. 9 x 5¾; x + 560; 1938.

This book aims high but strikes low. It consists of a series of chapters each contributed by a different author, apparently written without consultation. Just as a chain can be no stronger than its weakest link, so can the strength of a book be no greater than that of its weakest chapter. In this work the chapter on astronomy contains the statement that absolute motion in space can be detected, and that on physics that the mass of an object, if correctly measured, is constant for all observers. These premises are consistent with the classical physics of Galileo and Newton, and might have passed unchallenged a generation ago, but in the light of modern relativity physics they are no longer tenable. Einstein is mentioned in these chapters, but only in connection with some of his earliest work; there is no mention made of either theory of relativity.

On the other hand, the chapter dealing with mathematics is excellent. The treatment of the process of integration, while painfully brief, is more logical than that in any textbook which has ever come to the attention of the present reviewer. The same thing may be said about the discussions of imaginary quantities, the failure of the commutative law of multiplication in higher mathematics, and the non-Euclidean geometries. Saccheri receives the attention he deserves, but the name of Bolyai is unexpectedly absent.

The chapter dealing with psychology is extremely well written, as is also that on the philosophy of science. The remaining chapters are good, but do not strike fire from the imagination. There is an index of 17 pages.

SCIENCE IN GENERAL EDUCATION. *Suggestions for Science Teachers in Secondary Schools and in the Lower Division of Colleges. Report of the Committee on the Function of Science in General Education.*

Commission of Secondary School Curriculum, Progressive Education Association. D. Appleton-Century Co., New York. $3.00. 8½ x 5½; xiii + 591; 1937.

This report constitutes one of a series of publications to result from the Commission on Secondary School Curriculum appointed by the Progressive Education Association. In the first part of the book the purpose of education and the particular methods of teaching science in a democracy are considered. The main ideas developed here are borrowed from the writings of Dewey and his school. Emphasis is placed on developing children with distinctive personality, allowing the free play of intelligence, and fostering cooperation. Moreover, the teacher should give particular attention to the matter of social sensitivity, tolerance, and reflective thinking in the students. The second part discusses the methods of teaching science in relation to problems of health and disease, development of personality and ideas, sex and family behavior, social and economic principles. In the last two parts of this book, more and specific instructions are given relative to the individual personality problems of the children and a definite program is outlined. In substance then, it is proposed to teach particularly some of the practical aspects of scientific knowledge and to satisfy the immediate curiosity of the student rather than to try to make him understand the fundamentals of the ordered body of knowledge about a certain subject. There is much to be said in favor of such views although some objections could also be raised. In the first place, an attempt is made to use science as the justification of a particular political philosophy. This is always bad for science no matter how worthy is the ideal. In the second place, teachers able to execute such a program to the letter and actually increase the knowledge of the students must certainly be few in number because a tremendous store of learning is necessary to give an accurate and informative answer even to such a simple question as that regarding bread-making, for example, if one is to bring out its sociological, economic, biological, chemical and physical aspects.

A Philosophy for a Modern Man.
By H. Levy. Victor Gollancz, London. 7s. 6d. net. 7¼ x 5; 287; 1938.

This is an entertaining book dealing with a kind of practical philosophy. The laws of nature are first discussed from a general statistical point of view; then the changes in history and social developments in modern times. Practical questions are always placed in the foreground. In an introductory chapter the author characterizes his standpoint as follows:

> If a philosophy does not illuminate the practice of ordinary life, we maintain it fails in its function. It must be something drawn from the world of human affairs and guiding it. To lead a philosophy in this way from the barren wilderness of speculation into the rough and tumble of action is more than to violate the traditional meaning of philosophy.

Accordingly, some elementary assumptions are made in the beginning to illustrate the further philosophical development: (1) The universe exists; this we state as a truism that we shall not question. If it does not exist, its problems disappear with it. Those who question this need not proceed further with this book, the author says. The other assumptions are: (2) The universe is a changing entity; (3) Language is the liaison officer between the physical world about us, the actions, feelings, and thoughts about that world that flow within us, and the interpretation we pass on to each other; (4) Detailed changes show themselves within relatively permanent groups or collections; and (5) The universe contains also human beings with a changing consciousness of the material world about them, changing thoughts, feelings, perceptions and actions. The book will probably find many interested readers.

In the Spirit of William James.
By Ralph B. Perry. Yale University Press, New Haven. $2.00. 8 x 5¼; xii + 211; 1938.

This volume consists of the Powell lectures delivered at Indiana University and of some of the material already published in the author's Pulitzer prize work on

William James. The personality of this philosopher is presented to the reader as a contrast to that of Royce who like his friend James is also one of the great exponents of American philosophy. James, as the author describes him in the first chapter, was a cosmopolitan, a man socially minded, of ardent convictions and receptive to new ideas. His philosophical ideas are summarized in the following chapters which discuss his empirical theory of knowledge, the metaphysics surrounding it, and his liberalism manifest in theory and practice. One of the striking features of this presentation is the author's sympathetic interpretation of James's views and the strenuous efforts made to give his philosophy a consistency it admittedly lacks. Particularly pathetic appear the author's endeavors to answer definitively, in the light of his own and James's ideas, the question of when the liberal should use force in promoting liberalism. Although this book is primarily of interest to the philosopher it, as well as James's work, could and should be read by those dedicated to scientific studies. In particular, it would be well to keep in mind one of James's principles that in the search for truth all methods of approach are equally valid a priori.

ENCYCLOPEDIA AND UNIFIED SCIENCE. *International Encyclopedia of Unified Science. Volumes I and II: Foundations of the Unity of Science, Volume I, Number 1.* Containing the following articles: *Unified Science as Encyclopedic Integration*, by Otto Neurath; *Analysis and Synthesis in Science*, by Niels Bohr; *Unity of Science as a Social Problem*, by John Dewey; *On the Importance of Logical Form*, by Bertrand Russell; *Logical Foundations of the Unity of Science*, by Rudolf Carnap; *Scientific Empiricism*, by Charles W. Morris.

University of Chicago Press, Chicago. $1.00. 9½ x 6½; viii + 75; 1938 (paper).

FOUNDATIONS OF THE THEORY OF SIGNS. *International Encyclopedia of Unified Science, Volumes I and II: Foundations of the Unity of Science, Volume I, Number 2.*

By Charles W. Morris. University of Chicago Press, Chicago. $1.00. 9½ x 6½; vii + 59; 1938 (paper).

PROCEDURES OF EMPIRICAL SCIENCE. *International Encyclopedia of Unified Science. Volume 1, Number 5.*

By Victor F. Lenzen. University of Chicago Press, Chicago. $1.00. 9¾ x 6¾; vii + 59; 1938 (paper).

The *International Encyclopedia* is the seedling of a series of recent annual conferences devoted to the amalgamation of all branches of science. The first two volumes are being published as a background for the 1939 meeting and as an introduction to the volumes to follow. Otto Neurath explains in the first number that "The Encyclopedia is to be constructed like an onion" with this as the "heart". Other short articles enlarge upon the editor's introduction. John Dewey writes of the social aspects of scientific unity, while Bertrand Russell and Rudolf Carnap speak of logical form and terminology. But less like an onion heart than like an artichoke, most of these articles necessitate peeling off a lot of verbiage before one can get at the digestible portion.

The second number is a highly theoretical treatise designed to unify scientists in their diverse points of view concerning signs. Mr. Morris describes semiotic which is a panacea for scientific ailments, and particularly for our horrid language tangle, so sadly in need of "debabilization". The reader is run through the gauntlet of syntactics, semantics, and pragmatics, with their dimensions of semiosis and linguistic structures. And so the added babel of sign theory may make its contribution to scientific simplification.

"The problem of empirical science is the acquisition and systematization of knowledge concerning the things and phenomena experienced in observation." Mr. Lenzen expands on this at some length, discussing perception, measurement, and classification, both macrophysical and microphysical. The ideas contained therein are commonly known to scientific people. The final pages contain a good evaluation of the prospects for unity of science. This unity lies in the similarity of experimental procedure, although no single limited set of principles can be applied to all branches of science.

PROFILES IN HUMAN BIOLOGY. I AND II

By RICHARD RICHARDSON

[*Editorial Note:* It is ever the aim of the QUARTERLY REVIEW OF BIOLOGY to entertain as well as inform its clients. When we learned of the existence of the verses that will be included in the present series steps were taken at once to secure the exclusive rights to disseminate them to the eagerly waiting world of biologists. The expense was enormous, but service is our watchword.

The author of these *Profiles*, more of which may be expected to follow in later issues, is an American biologist of great distinction, who prefers to use a *nom de plume* in the present connection, for reasons that may become even more obvious as the series continues. Prosodiacally speaking Richard Richardson prefers free verse, of the shortest of short meter type. But in his case the form is not of first importance, for the same thing can justly be said of his writing that Edmund Clarence Stedman once said of Walter Savage Landor's—"His prose, though strictly prosaic in form . . . is more imaginative than other men's verses."

The breadth and variety of Professor Richardson's academic experience, instructional, investigative, and administrative, guarantee the soundness and penetrating quality of the observations about the various types of university fauna embodied in the *Profiles*. A worldly wisdom as vagarious as it is vagissatory will make itself evident as the series unfolds. βραχεῖ λόγῳ καὶ πολλὰ πρόσκειται σοφά].

I

THE PEDAGOGUE

HE STALKS about our Land
Teaching young things to teach
What they do not know.
He has all the solemn dignity
Of a funeral director
And usually a leonine
Head of iron-gray hair.
He flocks to conventions,
"Panel discussions"
And conferences.
To him gregariousness
Is more stimulating
Than alcohol.
His speeches usually begin
With the trials of his youth
And end
With a plea for more taxes.
(If he knew Latin
He would intone:
"Ita missa est.")
Anyone who takes the trouble
To teach himself
Is "underprivileged."
(How does he think learning
Came into this world?)
Still—
I probably do the crew an injustice,
For I understand there are several
Who have read a book.
But, on the whole:
"They'll none of 'em be missed—
They'll none of 'em be missed."

II

THE ECONOMIST

BEHOLD the Economist,
Who is "cock-sure that everything
Is up to him,
And he is up to everything."
He is industrious
And computes
Elaborate indices
To the fifth decimal place—
Including the current price of zebras
In the Zoo

And the last scanty remnant
Of the modern bathing suit.

Yet his is a science
Based upon a single sin.
Why did he choose Avarice
When so many other deadly sins
Are more pleasant?
Probably because
It begins with the first letter
Of the Alphabet.
He is sceptical
Of the Mystery of the Trinity,
But is faithful unto death
To the Mystery of the Currency.

He has yet to explain a medieval cathedral,
A Rodin
Or an Icelandic saga.
But that's all right!
He has never heard of them.
For his concepts of history
Are curious.
He is forever
Confusing
Adam Smith
With Adam.

Some day
We shall erect
A monument
In his honor.
But perhaps it will be kinder
To leave
The inscription plate
Blank.